TELESCOPE MAKING 19

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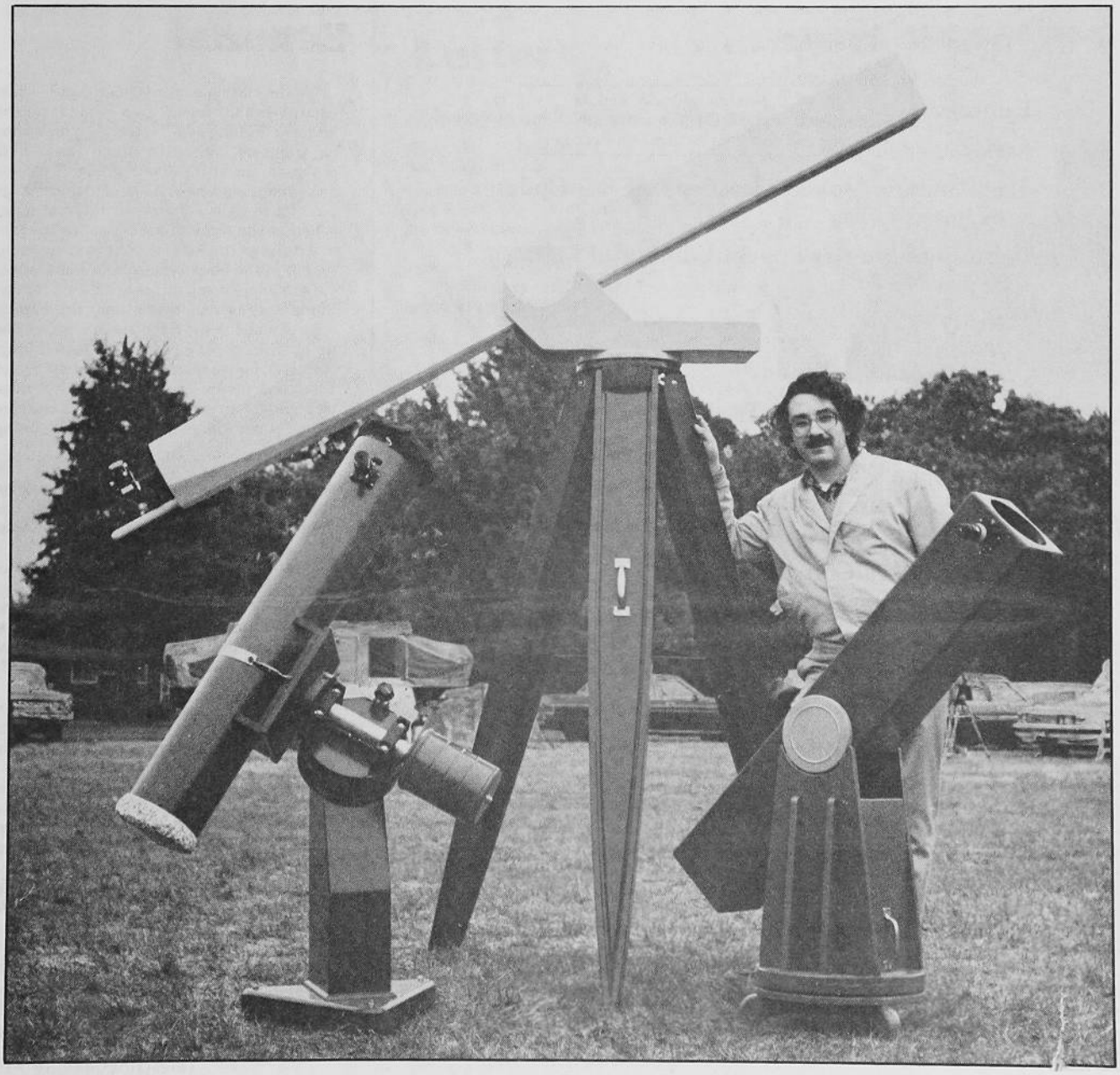
The magazine *for*, *by*, and *about* telescope makers!

Spring 1983



TELESCOPE MAKING

The magazine *for, by,* and *about* telescope makers!

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If you live in the midwest, look in the envelope your TM just arrived in. You should find this year's AstroFest flyer in it.

Cover: "The World's First 6″ Dobsonian Refractor" might not *really* be the first, but it *is* a 6″ f/15 Dobsonian refractor. Exhibited at AstroFest '82 last fall, this instrument built by Richard Berry features a sturdy wooden tripod 74″ tall surmounted by an "offset rocker box" with a 30-pound counterweight. The tube is made from ¼″ plywood.

Editorial

"At the cutting edge of technology" — just what does that mean? In a sense it means nothing: "cutting edge" is merely a metaphor for progress. But in another sense it is profound, for at the "cutting edge," we see new things and new ways of doing things brought to light — done for the first time. Whether you think of the "edge" as the tool of a lathe or the knife guided by a surgeon, we cut at the boundaries of our knowledge.

Technologies can be many different things. Stone axes were, at one time, the cutting edge of technology. Spyglasses were, at one time, the cutting edge of technology. Hundredth-wave massive optics for the Space Telescope optics are today's cutting edge technology. In amateur telescope making today, equatorial platforms are that cutting edge.

Something as simple as an equatorial platform shouldn't be advanced technology, should it? After all, you or I could build one in our basement with ordinary power tools. We wouldn't need a clean room, or a microcomputer, or any of the other things we tend to associate with new technologies. But technologies are really nothing more than *ways of doing things*. These devices, mechanically simple as they are, will bring us new abilities when they are finally developed.

As with all new technologies, we have seen both promising leads and false starts. The best geometries and materials have yet to be worked out. Were Teflon bearing surfaces a false start? What are the relative merits of nested-corner, Pursell platforms, and the classic Poncet? We really don't know; there is more to do before today's developing platform technology becomes old hat.

The best platforms provide the kind of performance we expect from a good equatorial — Tom Migiel's provides tracking with 5 to 10 arc-second errors — good enough for most applications. The big companies are interested, too, looking for ideas. Read between the lines (or right on the lines) in Celestron and Meade's recent

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Employment Opportunities adverts: "alt-azimuth guiding platforms" and "ultralight telescope design" are in there alongside the computer stuff.

An apology for TM#19's tardiness. We're right on schedule in that we're going to go to press 12 weeks after TM#18, but we're running about a month behind the calendar date we should have come out. I've gotten a surprising number of letters from people saying, "I don't mind your being a little late, but please don't go out of business."

I'm glad that you like TM that much but please remember the very most sincere way to say "we want you" is to *renew your subscription* when the time comes. Don't put it off when the bill comes — pay it right away. Nothing speaks as eloquently to a company's management as "high renewal percentage" and a steady growth in circulation. TM has done both, but we still need you, and we always will. Oh yes — get your friends to subscribe, too!

Well, just a few notes on TM#20. Maybe the completion of five years of publication doesn't mean much to the average reader, but we editorial types keep thinking "Omigod, you mean it's been that long!?" We plan to celebrate — sort of — by putting out a bigger-than-normal 64-page issue with cumulative index to back issues. More work.

Finally, this year Bob Cox will be covering the Riverside meeting for us, Dave Eicher will be at the Texas Star Party (for *Deep Sky* magazine), and I will be at Stellafane. I'd love to be at Riverside, too, but I'll be in Hong Kong on my way to Indonesia for the solar eclipse. This will be the fifth time I've traveled somewhere to see a solar eclipse — I hope I won't be clouded out this time, too!

Sincerely,

Richard Berry

Richard Berry
Editor

Letters

Observing Chair — Cheap

Dear Sir / Although I have seen other examples of observing chairs, they were more expensive and complicated than I felt I was capable of. So I came up with my own design. Its advantages are:

(1) Low cost, I built it for $0.00 except paint.

(2) Minimum tools: hammer, handsaw, screwdriver, drill and ¾″ bit.

(3) Two hours to build.

The pictures explain more than a thousand words could, however a few comments are necessary. The basic ingredient is the base

of an old office chair that swivels and tilts back. I found mine at the local dump, missing a seat and a back. I added a new seat and back on, plus a lawn chair adjuster. I also added a chart table off to the side with scraps from a new home construction site.

It is important to note that the center of gravity when you are in the horizontal position will cause the chair to tilt backward unless the plywood seat is attached to the base as far back as possible.

Since the chair has the ability to tilt back, I only found it necessary to put three stops or notches in the back of the lawn chair adjuster.

For comet and nova sweeping as well as just cruising the Milky Way with small, low-powered richfield instruments, this chair offers cheap relief from fatigue and neck ache.

Daniel Boone
143 Teresa Ct.
Elizabethtown, KY 42701

All Things Considered

Richard / The article by H.G. Rutten & M.A.M. van Venrooij in TM#18 was an excellent one. I would like to extend their discussion and consider some important practical aspects of telescope design, performance, and construction.

1) They state that a field flattener introduces its own coma and astigmatism. While this is true, if the flattener is close to the focal plane, then its effect on coma and astigmatism is neglible. The cost is quite small if you have it made, and it easy to make yourself since the optical tolerances are quite loose.

2) Furthermore, though it unfortunately did not make it into my *S&T* article, the field corrector lens does more for the SIMAK than just flatten the field. It also corrects the residual lateral chromatic aberration of the

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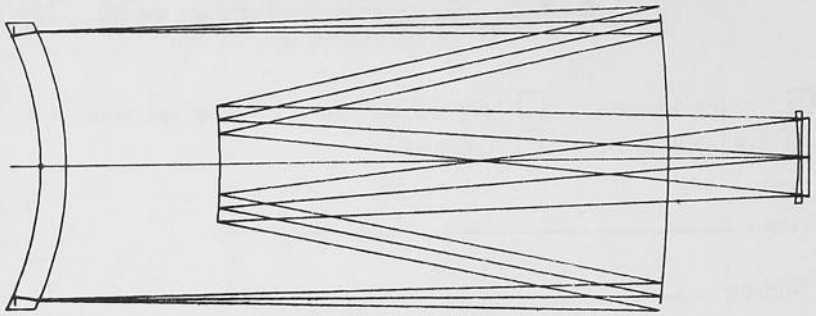
Letters



system. So, the SIMAK is really intended for use with the field corrector, even though it does fairly well without it, especially over the format for which it is designed.

3) Since critical focusing is, at best, difficult with an SLR's ground glass screen, a practical and effective way to build a system is to buy a roll film back (Mamiya RB-67 or Hasselblad) and build your astrocamera around it. The field corrector is then a simple matter to include in the design, and can even be an integral part of it, serving as a vacuum window for a cold camera if that is what you want. Compared to the rest of the scope, the effort of making and installing a field corrector is insignificant considering the improvement it makes.

4) A SIMAK (by my own definition) must be corrected for longitudinal chromatic, spherical, coma, and astigmatism to qualify as a true SIMAK. The design presented in the articles (possibly due to a misprint) does not quite achieve coma correction, which you can see in the spot diagrams, although it is close enough that it doesn't degrade the images more than 25% or so.

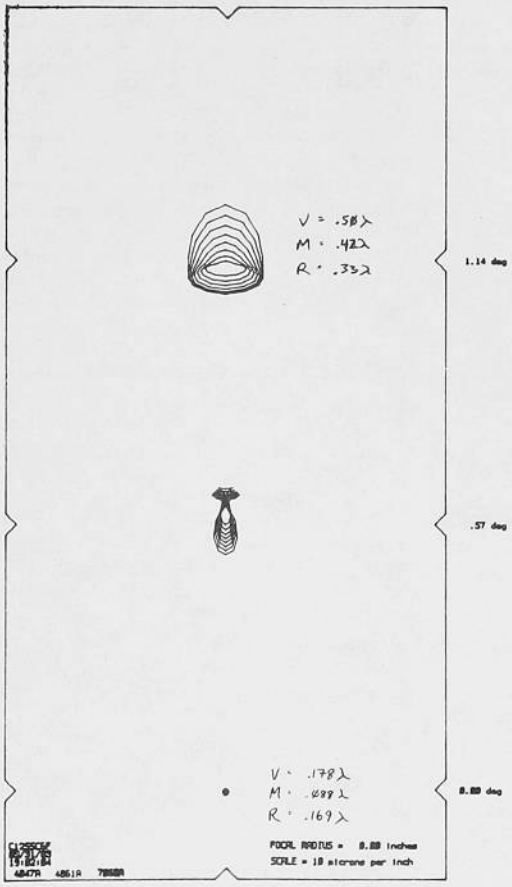
5) To say that "these instruments can hardly be used visually" because of the large obstructions is not true. I and many others have observed through SIMAKs of 8.5″ to 11.5″ aperture many times, and I can assure you that it is an excellent visual telescope for deep-sky observing as well as photography.

6) The obstruction of the SIMAK is smaller than the other designs (according to the authors' table) despite the fact that they specified it for 100% illumination over the entire 6cm field for the SIMAK. As the authors point out, it is entirely reasonable (and wise) to let the illumination drop off by 30% to 40% at the corners of the field; you just don't notice the difference and it reduces the central obstruction size.

It is difficult to write a comparison article like the one in TM#18. Perhaps the most difficult part is avoiding the pitfall of comparing apples and oranges. I can see that the authors tried to do this, but when they compared all of the systems over the same linear field size, they were not showing the performance of the systems over the fields for which they were designed. Since the performance of most optical systems "goes to hell" very quickly beyond the field angle for which it is designed, this can be misleading. The extreme variation in angular field size covered by the various designs is evidence that the designs are intended for entirely different kinds of astrophotography.

Since it is so difficult to write a comparison article, I think it would be a good idea to include an "all things considered" section at the end that brings the practical aspects of the designs into focus for those who are not so familiar with the numbers, terminology, and implications of optical design or application of the instruments discussed. For example, note that the SIMAK and Sigler Maksutov have only spherical surfaces and the secondary mirror in the SIMAK is close enough to the corrector lens so that it can be (and always has been so far) attached to the corrector, avoiding the side effects of spider vanes, the extra work, the diffraction spikes, the extra difficulty of achieving and maintaining perfect optical alignment in all tube orientations, etc.

To the best of my knowledge, every SIMAK built so far stays in perfect alignment because they are built that way to start with and stay that way due to the fact that there is no



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	Radius	Position	Index	Shape	Offset	Size	Tag	#	Glass
0	0.0000	0.0000	1.0000	1.0000	0.0000	6.0000	0		
1	0.0000	0.0000	.6569	1.0000	0.0000	6.2500	0	225	BK-7
2	61.9500	.2500	1.5224	6.7000	0.0000	6.2500	1	225	BK-7
3	-60.0000	19.6000	-1.0000	1.0000	0.0000	6.5000	0	1	Quartz
4	-37.5000	.7750	-1.0000	-3.4000	0.0000	2.5000	0	1	Quartz
5	525.0000	21.9750	.5536	1.0000	0.0000	2.0000	0	412	SF-11
6	-525.0000	22.2250	1.0065	1.0000	0.0000	2.0000	0	412	SF-11
7	-5.0200	26.6500	.6569	1.0000	0.0000	1.7500	0	225	BK-7
8	-7.8943	27.0000	1.5224	1.0000	0.0000	1.7500	0	225	BK-7
9	0.0000	28.0403	1.0000	1.0000	0.0000	1.5000	0		
Zones	0.000	3.000	3.969	4.743	5.488	6.000			

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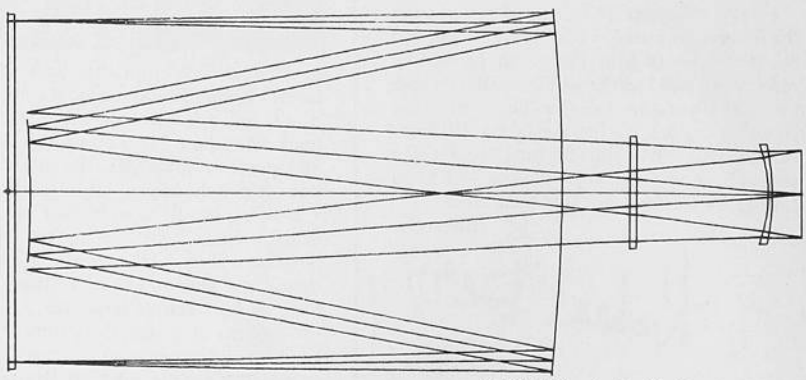
Focal Length ===>> 75.57040629174
Focal Ratio ====>> 6.298200524311



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collimation system at all; the collimation system itself is the chief reason telescopes go out of alignment when they are transported and pointed at different parts of the sky. Note also that the SIMAK is more compact than the other easy-to-make types.

I think that all things considered — the difficulty of optical fabrication, the difficulty of mechanical fabrication, the size of the tube assembly, the size of obstruction (and therefore the class of applications that it is suited for), the sensitivity and likelihood of collimation difficulties, the inclusion of the field corrector in all the systems, the expense of construction, image quality (optical performance), etc. — it is clear that the SIMAK is designed with the practical aspects of actually building and using a telescope in mind to a degree not shared by the other systems.

For comparison, I have designed a 10″ f/8 SIMAK that is intended for a 3″ (75mm) diameter field. Its residual spherical aberration — with all spherical surfaces — is less than $\frac{1}{10}$ wave and the multichromatic errors at full field are considerably less than 25 microns (and less than ½ wave) despite the fact that this is a 10″ aperture telescope as compared to the 8″ designs in the article.

In addition, I present a new Schmidt-Cassegrain design I have recently developed. It is designed for precisely the same sort of astrophotography as some of the designs presented in the article, and should thus be of interest. (Two very similar 24″ f/6 telescopes with even better performance are being constructed at this time, but I did those designs under contract and thus are proprietary. Both cover a 7-inch diameter field.) The design presented here is 12″ f/6 for 6x7cm photography, the same 3″+ field diameter as the other telescopes. Again, the performance is under 25 micron (and under 1 wave) over the entire flat field and requires an obstruction less that 50% to fully shield and properly illuminate the field. It can also be used without the field correctors for visual observing and smaller format photography.

Note that in both cases, I have left the residual spherical aberration of the system when running these optical analyses, unlike in the TM#18 article. When the system is totally nulled by the optician, the spot will become somewhat smaller (about 25% or so) and the fact that the total aberrations are less than 1-wave over the entire field means that the effects of the aberrations will be to lessen the perfection of the diffraction disk rather than generate a blur of the size shown.

I am willing to share the specifications on these two systems and correspond with ATMs that are seriously planning to build a photographic telescope, but please include a large SASE.

Mike Simmons
4440 E. Ina Rd.
Tucson, AZ 85718

Reality Vs. Raytrace

Dear Richard / We would like to caution your readers on drawing hasty conclusions from the raytrace diagrams, especially now that more and more of these are being presented in articles on photographic optics these days. We have done considerable work on the matter of photographic resolution, and will soon have an article in the *AAS Photo-Bulletin* on factors that influence the lower limits of photographic resolution. We are now in the process of finishing up work on the factors influencing the shapes of heavily exposed star images, and hope to get an article out on this in a while. The raytrace does not accurately predict the photographic image you're going to get — and in this sense, a raytrace does not reflect reality! This is especially true when a small number of points are tossed into the computer in a regular array and then bounced and scattered about to form the final image pattern. The use of a few points, combined with the use of a regular data array, really destroys the information that can be obtained by raytrace work. A random array is to be preferred at all times, and no fewer than 200 points — preferably many more — can be used if one is to get an accurate idea of the image structure. Even this small a sample cannot be expected to give an image that matches

100 dots, Regular | 200 dots, Regular | 400 dots, Random

reality, as there are many flaws in the entire procedure, especially when photographic emulsion is involved:

1) The intensity of the image at various points is largely lost in the raytrace diagram, or is not immediately evident.

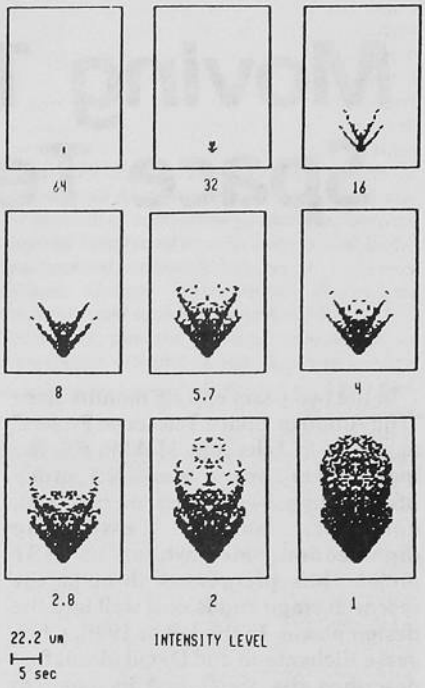
2) The photographic emulsion disperses the image.

3) The faintest portions of the image are not recorded on the film until long after the image has grown considerably due to the general dispersion, reflection, and scattering of light in the photographic emulsion layer and its backing.

4) According to the raytrace, all of the points from a star on axis are imaged back to a single point. This "point" image is, in reality, an Airy disk surrounded by diffraction rings. Its dimensions should not be ignored.

What this means to the practical astrophotographer is that the longest comatic tail ever seen in a photographic image is shorter than anything predicted by raytrace by a factor of at least two. To demonstrate why this is so, we have prepared raytrace diagrams for a 6-inch f/6.0 instrument and a star image 1.0 degrees off-axis. Some 4900 random points were generated, and a histogram array of the frequency at which a single pixel was hit was formed. Using this array, slices were then taken through the 3-dimensional raytrace spot diagram (dimensions = x, y, intensity) and the following series of diagrams were made showing the effect of increasing intensity upon the size and shape of the spot diagram.

"Intensity Level: 32" means that only those points receiving more than 32 hits are plotted in that associated diagram. The 22.2μ scale bar at the bottom is as small as most amateurs will ever see using such an instrument with 103a-films, but the real lower limit on star image sizes for this instrument is around 18μ. These diagrams shed a lot of light (or rays) on the formation of the star image for us; hope they do so for some others as well!



Without such elaborate treatment, the information that can be derived from a spot diagram would seem to be of use only when all of the points get concentrated into a small, symmetrical image that is uniformly illuminated. For example, the raytrace information on the Concentric Schmidt camera and on the Simak (in Rutten and Venrooij's article in TM#18) is relatively easy to interpret, and closely mimics reality. However, if the raytrace diagram gives some clue that the intensity is not uniform, one should be very careful about concluding that the system is not of use for astrophotography! There are very few systems that outperform a Newtonian, and a Newtonian with a field corrector is really hard to beat.

Let us conclude by saying that we really think TM is a great magazine, and we think that a lot of good things are being said because it is apparently free of the pressures of being supported by big telescope makers. TM presents a forum that has not been available and may well be having an impact upon the quality of products that are being made available to amateurs today. (Brad's only complaint is that he can't stand articles on building observatories. Always complaining about something!)

Brad D. Wallis
Robert W. Provin
1917 Meadow Brook Ct
Thousand Oaks, CA 91362

— Thanks for your commentary on a complex topic. Just a comment on Simmons' point 5: when I edited the article, I simply passed over the statement, interpreting it as applying to high-power viewing and the

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ISRG

Moving Toward the Amateur Space Telescope and Beyond

by Robert F. Pfeiffer

In the two years and six months since "The Amateur Space Telescope Project" appeared in Telescope Making #9, the Independent Space Research group (ISRG) has grown into an international, nonprofit, amateur astronomy organization. Meanwhile, its AST project has progressed through the research stage and is now well into the design phase. In the fall of 1980, when Jesse Eichenlaub and David Marat first described the ISRG and its goal: to build, launch, and operate an amateur space telescope, the fledgling organization consisted of 20 members centered at Rensselaer Polytechnic Institute (RPI). The organization now boasts over 250 members in twelve countries, and receives valuable financial support, services and equipment from interested corporations and individuals. In addition, the ISRG has expanded its operations beyond RPI to the University of Rochester, where the group now sponsors its Optics and Optical Detectors project teams. Overall, despite several changes in plans and design, the Amateur Space Telescope Project is moving swiftly toward its projected launch in late 1984.

Changes in the AST Program

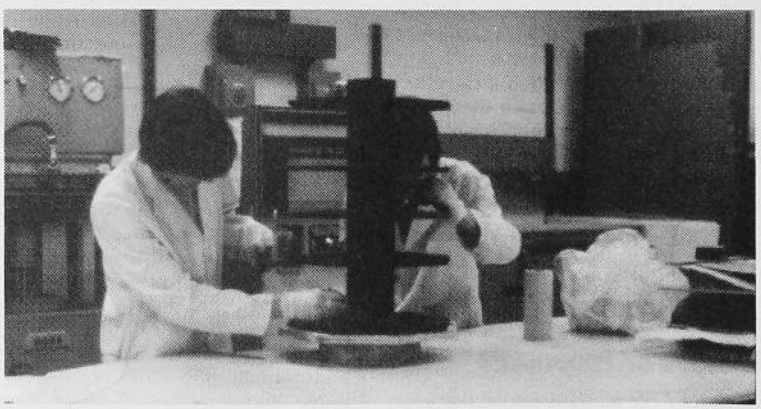
According to the original schedule of operations, the ISRG planned to develop and test the AST project in two distinct phases. First, the group would construct a Test Satellite, for launch via a "Get-Away Special" (GAS) cannister during a Space Shuttle mission sometime in 1982. Once in space, the Shuttle would eject the Test Satellite into a low Earth-orbit. The satellite would contain all of the AST functional components except the telescope optics, enabling the ISRG to "live" test the AST's attitude control system. Second, following the test satellite experiment, the ISRG would complete construction of the actual space telescope satellite and launch it late in 1984, either in a Shuttle GAS, or "piggy-backed" on a conventional rocket.

However, difficulties in arranging an orbital launch have forced the ISRG to modify its original operating plan. Although the Inter-Space Society donated a five cubic foot GAS to the ISRG for use in a spring 1983 Shuttle mission, NASA has no plans to allow ejections from GAS's before 1985, if at all. Thus, the ISRG must now rely on a conventional rocket piggyback launch for any satellite it wishes to send into orbit during the next several years. Along these lines, the California-based Gary C. Hudson (GCH) Industries has expressed interest in providing launch space for the AST project aboard one of its Percheron rockets.

The ISRG had planned to arrange for the Test Satellite launch with GCH Industries sometime in 1983. This would allow the group to keep pace with its projected late-1984 AST launch. Unfortunately in 1981, GCH Industries lost one of its largest financial backers over differences in opinion concerning rocket design, and has temporarily shelved the project until new backing can be found. Thus the earliest possible date for an ISRG launch on a Percheron rocket is now the spring of 1984.

Update on the Project Plans

Since no satellite launch for the AST project is possible before 1984, the ISRG faced the prospect of either pushing the project deadline back well into 1985, or sacrificing a separate Test Satellite in order to ensure project completion by 1985. At this stage it is certain that the ISRG will abandon work on the Test Satellite and redirect its efforts toward the AST itself. Instead of the "live" satellite test, the ISRG plans to take advantage of the Inter-Space Society GAS cannister aboard a Shuttle in 1983. Components which were due to be tested on the satellite instead will be placed in the GAS and tested without



Matt Cockett and Andy Bertolozzi work on mockup of AST equipment bay structure.

Left: *RPI Engineering students Alex Farinas and Alec Gilmore make the first cut in a roll of composite graphite-epoxy material being used to construct the GAS test payload mounting structure.*
Below: *George Van Heusen, Jr., a machinist and amateur astronomer from Scotia, NY, puts the finishing touches on a prototype attitude control flywheel.*

release from the Shuttle. The advantage of using the GAS is that the Shuttle will return the equipment to Earth after the test, allowing the ISRG to modify the equipment as necessary and then incorporate it into the actual AST. This will save the group time and money.

In addition, ISRG members believe that "scrapping" the Test Satellite will not deny them otherwise invaluable testing opportunities. The original purpose of the Test Satellite was two-fold. First, it would test the orbital response of the same attitude control system designed for the AST. Second, it would act as a "training satellite," providing the planned earth-station communication network with experience controlling a communications satellite. Now, however, the attitude control system advisor feels that the use of current, specially designed, computer software will allow the ISRG to simulate — on the ground — low-earth orbit conditions to accurately predict the operational behavior of the attitude control system. This will make actual orbital testing unnecessary, and allow for rapid system modifications.

As for satellite training, if ISRG members need communication practice, OSCARs (the "radio ham" satellite) are already available for that purpose. But there will probably be less of a need to gain practical experience, as the ISRG plans to use some communications stations in the Radio Amateur Satellite Corporation (AMSAT) network. As these stations are already advance-automated and staffed with experienced personnel, no need for practice exists. The ISRG is also interested in working more closely with AMSAT in the future. For example, communication between the AST satellite and ISRG earth-stations may be provided via a radio link through AMSAT's Phase 3 and Phase 4 satellites. Several of these satellites should be in geosynchronous (fixed point) and geosynchronous transfer (temporary fixed point) orbits by 1985. In this system, the AST would send radio signals from its constantly changing location to the AMSAT satellites which would relay the information to earth stations.

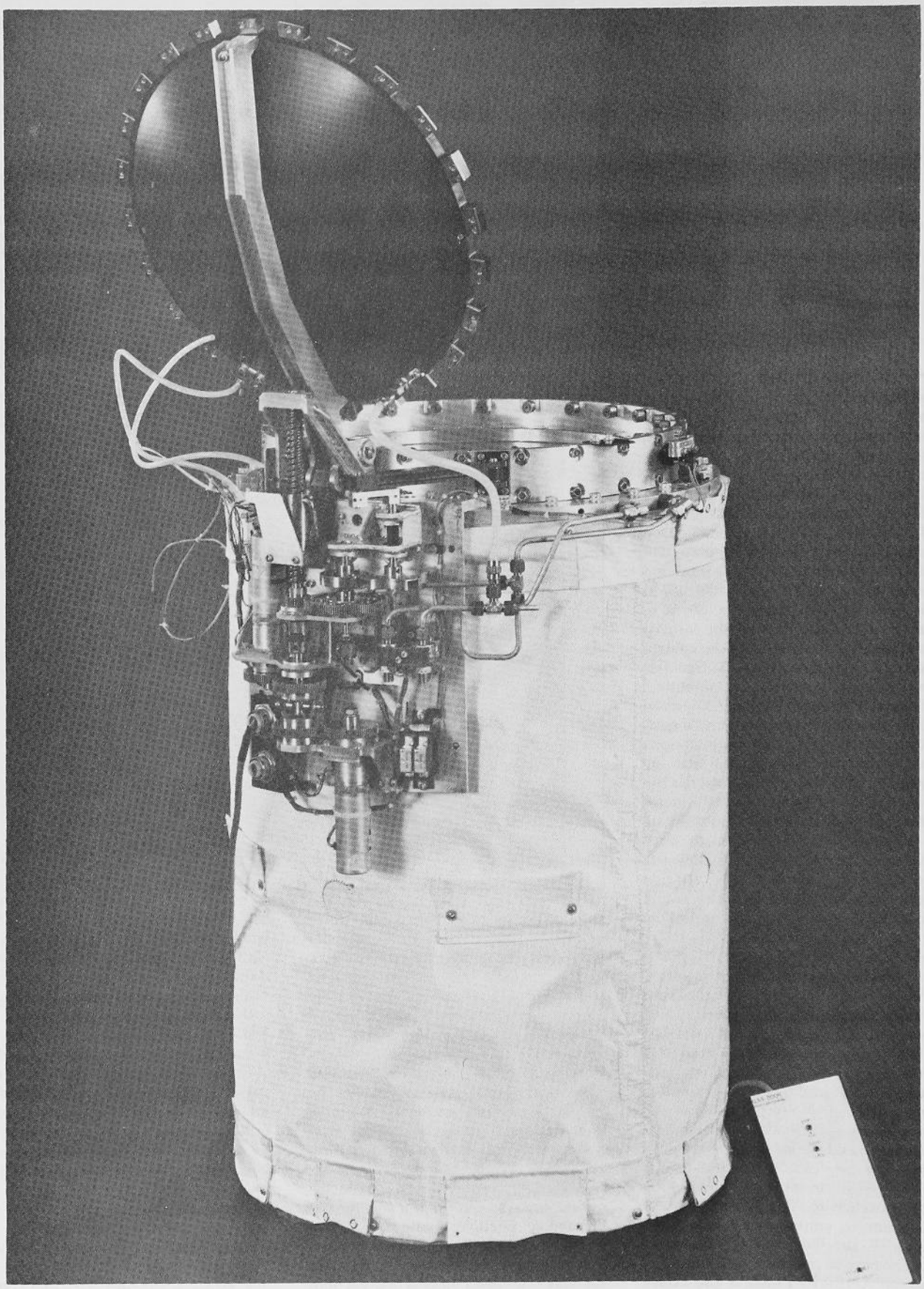
Equipment Test in a Shuttle GAS

According to Jesse Eichenlaub, the "payload" for the GAS launch is almost fully designed and most of the pre-testable systems now undergoing evaluation. Project teams currently are re-designing certain systems to incorporate some last-stage improvements. Following positive evaluations, the project teams will begin construction and assembly of the critical component systems scheduled for thermal-vacuum and vibration-stress testing in the GAS. The following systems and equipment will fly into orbit aboard the spring 1983 Shuttle mission:

- the satellite equipment bay structure;
- all mechanical systems;
- the attitude control flywheels;
- the storage batteries; and
- the system microprocessor.

If the tight construction schedule permits, Eichenlaub also hopes to include the project's television camera and lens system in the GAS cannister, as a window may be available in the cannister allowing the ISRG to test the camera equipment.

Design work for the AST satellite itself is also nearly completed. Construction work on the satellite will coincide with work on the GAS test systems, and when the test equipment returns from its space flight, ISRG members will make



necessary modifications in the systems according to the test results. They then will assimilate those parts into the satellite along with the completed telescope optics, which will be completed by then. Once assembled, the AST will face final evaluation and testing, then await its ride into space and a 300 nautical mile sun-synchronous (non-fixed point) polar orbit.

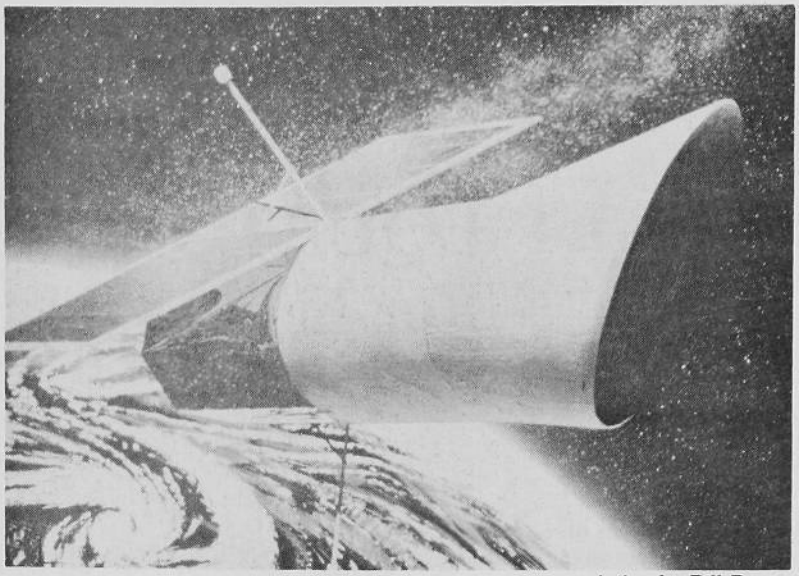
Support for the AST Project

Financially, the ISRG has grown from an unsupported idea three years ago into an international and self-productive group on the verge of making amateur astronomy from space a reality. The organization often depends upon the generosity and patronage of space groups, industries, and outside individuals. Besides the queued GAS cannister donated by the Inter-Space Society, and the launch space offered on a GCH Industries Percheron rocket, other companies have donated composite structural materials and aluminum honeycomb sheets for use in the telescope satellite's solar panels. Several individuals have also provided the ISRG with oscilloscopes for ground research.

In addition, early this year the International Space Corporation (ISC) of Florida pledged $10,000 to the ISRG for use in 1982. This gift will cover remaining costs incurred in the construction of critical systems for the GAS flight and tests. Any of the money left over from that phase of the project will enable project teams to begin work on the AST satellite itself. While the donation from the ISC will help in the push toward completion of the Amateur Space Telescope satellite, the ISRG hopes to locate more corporate members to help meet further costs.

While outside groups and interests have provided much needed materials and support, the ISRG would be unable to function or meet the AST's costs without the financial and technical dedication supplied by its individual members. The group's increasing membership, largely due to the interest of amateur astronomers, has provided endless skilled free labor and raised over $4,000 through dues for off-the-shelf parts, and project research and design. However, much additional time, effort, and support are needed in order to ensure the project's success. As a result, the ISRG is constantly looking to increase its membership with skilled, or just interested, space and astronomy enthusiasts.

A GAS container for the equipment bay structure test. NASA photo.



painting by Bill Beaty

The ISRG has now begun construction of the GAS test payload. Current membership rates are:

$15 Supporting
($20 overseas)
$25 Patron
($30 overseas)
$50 Contributing

Future Developments

Despite the problems encountered in finding a suitable AST launch method and time, the ISRG remains optimistic about the future of amateur space astronomy. Members see the expansion of operations to the University of Rochester, the increasing membership and financial support, and the already numerous requests for experiment time on the space telescope as assurances of continued growth beyond the AST project.

In fact, the group already is discussing the possibility of a follow-up "AST-2," which might contain a larger, one-meter special purpose ultraviolet or infrared telescope. Another post-AST priority might be a solar sail propelled Amateur Lunar Orbiter which would provide useful information on the Moon's geology and resources. In fact, a feasibility study on an Amateur Lunar Orbiter, supported by a $1,000 contribution from the International Space Corporation, is now being conducted. Although these projects are years away, they prove that where the ISRG is concerned, the sky is not the limit — it is only the beginning.

Anyone interested in ISRG membership information, or wishing to know more about the AST should write to:

The Independent Space
Research Group
P.O. Box 1246
Troy, New York 12180

Robert F. Pfeiffer
21 Clinton Avenue
Kingston, NY 12401

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A State-of-the-Art PONCET EQUATORIAL PLATFORM for large reflectors

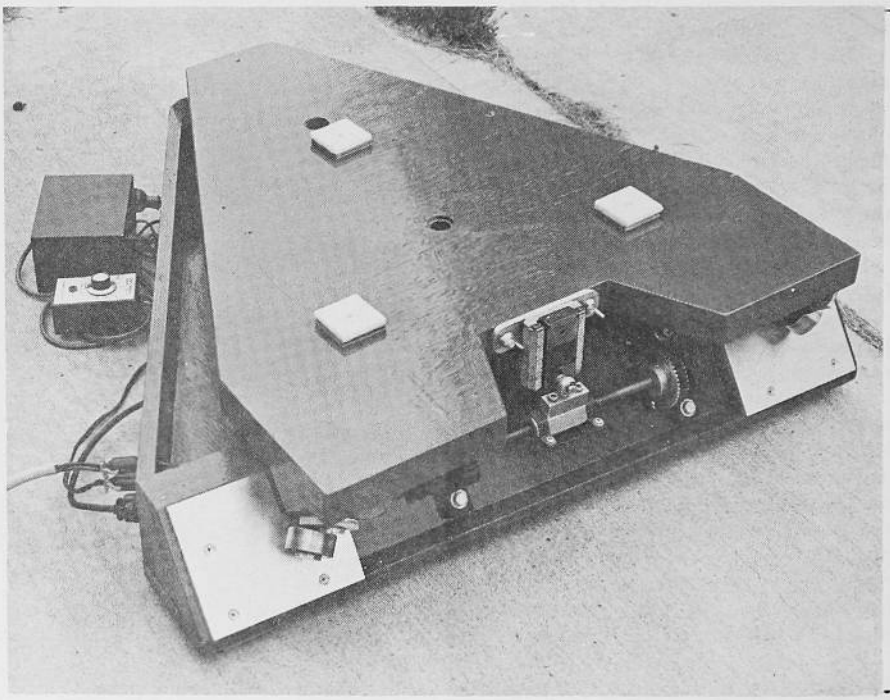
The Poncet platform described here is the result of the one major drawback of Dobsonian (alt-azimuth) telescopes: their inability to counteract the Earth's rotation. Since I frequently use my 17½" Dobsonian telescope at public star parties, there are sometimes dozens of people waiting their turn at the eyepiece. It is frustrating and time-consuming to have to constantly align the telescope back on the object after each person has looked through it. And, of course, whenever I'm out observing without some sort of drive, the object zooms through the field in a matter of seconds if I'm using high powers.

Without going into the expense of building or buying a fully equatorial mount, the Poncet platform seemed like the logical choice.

After going through the literature that was available on Poncets, drawing a few designs on paper, and talking to some very helpful friends, I began construction in April 1982 so as to have it ready for the Texas Star Party the following month. I was still working on it the day before I left for Texas and was not fully tested until I arrived there — however, after only a few minor adjustments, the Poncet platform worked just fine, so I got to enjoy a week of beautiful dark Texas skies.

The main criteria for the platform was that it be as sturdy as possible, as should any telescope mount, but also as small and low as possible. Since I had previously built a smaller Poncet platform for a smaller telescope, I knew that the parts on the large Poncet would have to be beefed up to carry the larger 257-pound telescope.

As the Poncet began to take shape, it became apparent that certain parts had to be made extra strong. One problem that took me by surprise was the flexure in the upper platform. When weight was applied on top of the Poncet,

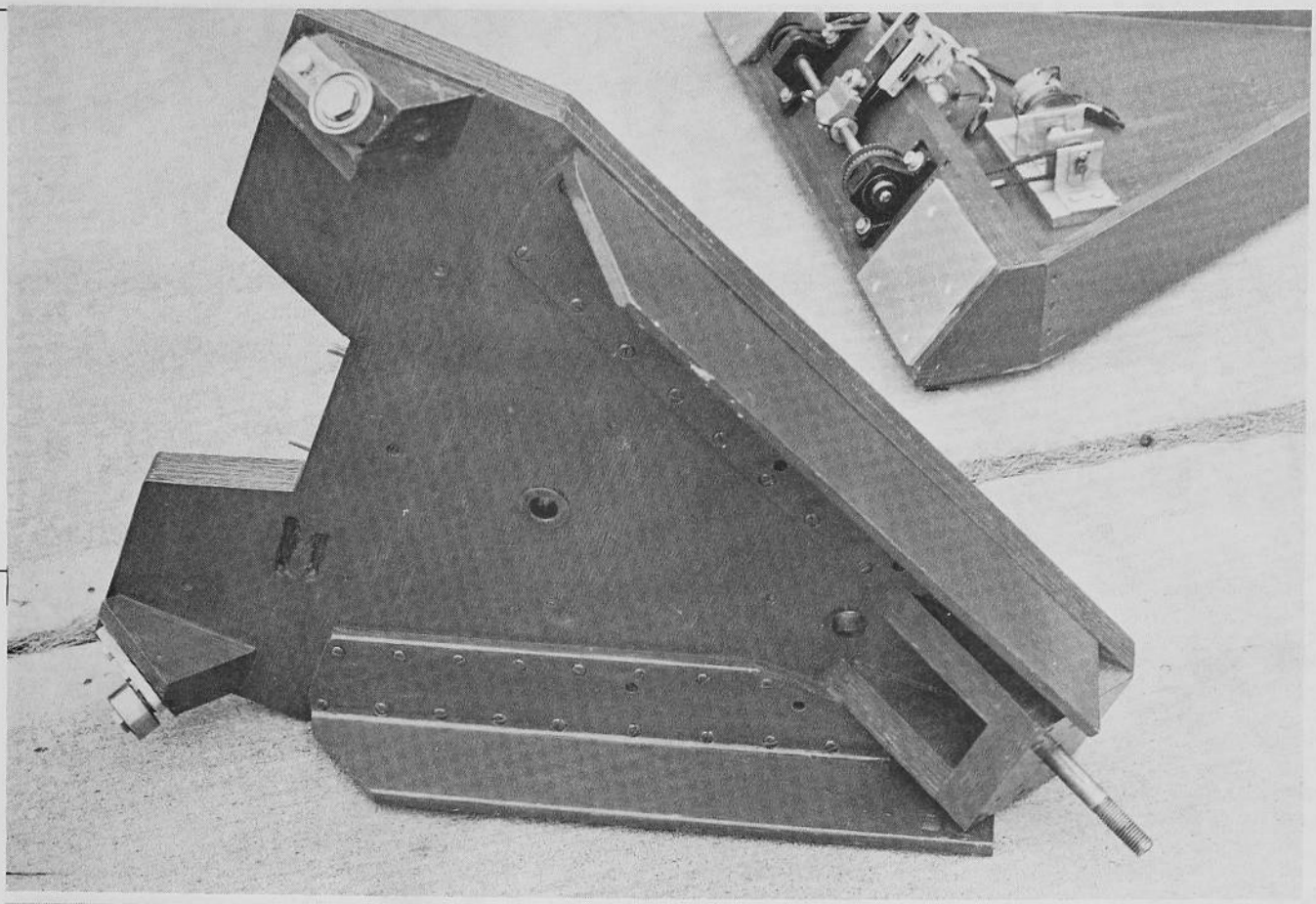


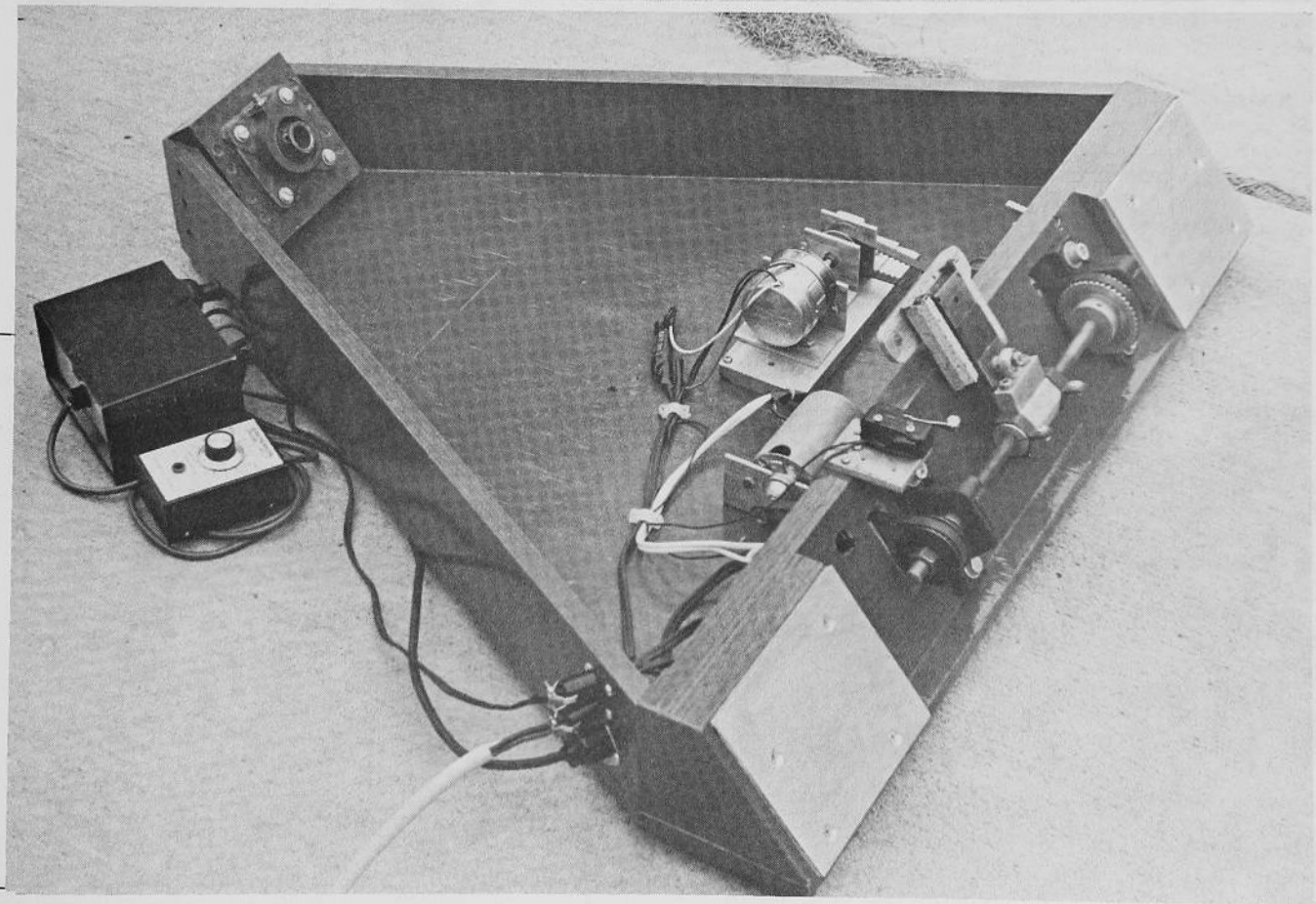
the 1½" thick upper platform flexed like a springboard. This would not do! I solved it by attaching two pieces of 4" angle aluminum underneath the upper platform, attaching them to the edges of the upper platform so as to clear the mechanical structures inside the lower triangular box.

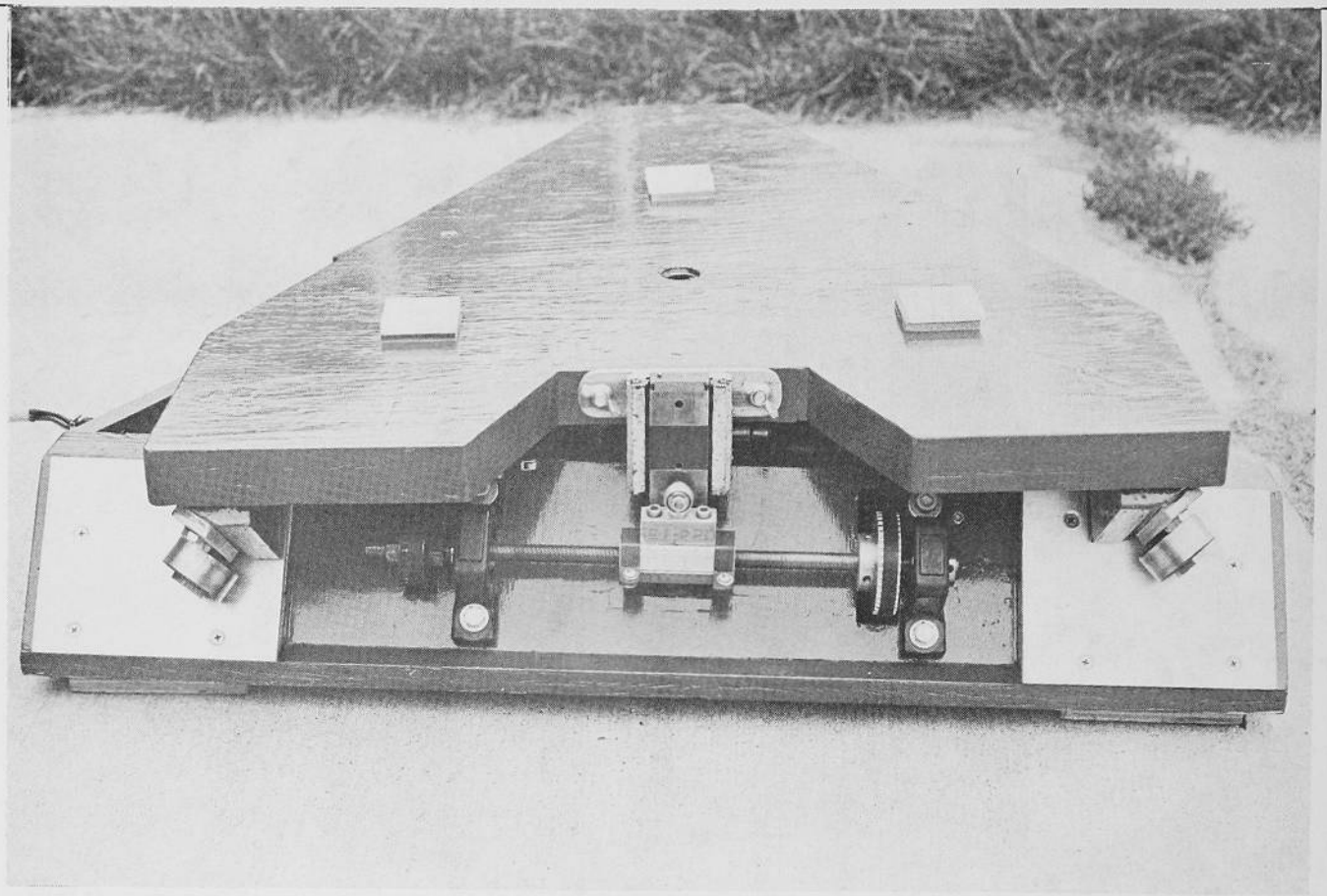
The drive mechanisms were designed by a fellow club member, Gary Ruisinger. He got most of the parts from out-dated computers and printers that were being scrapped.

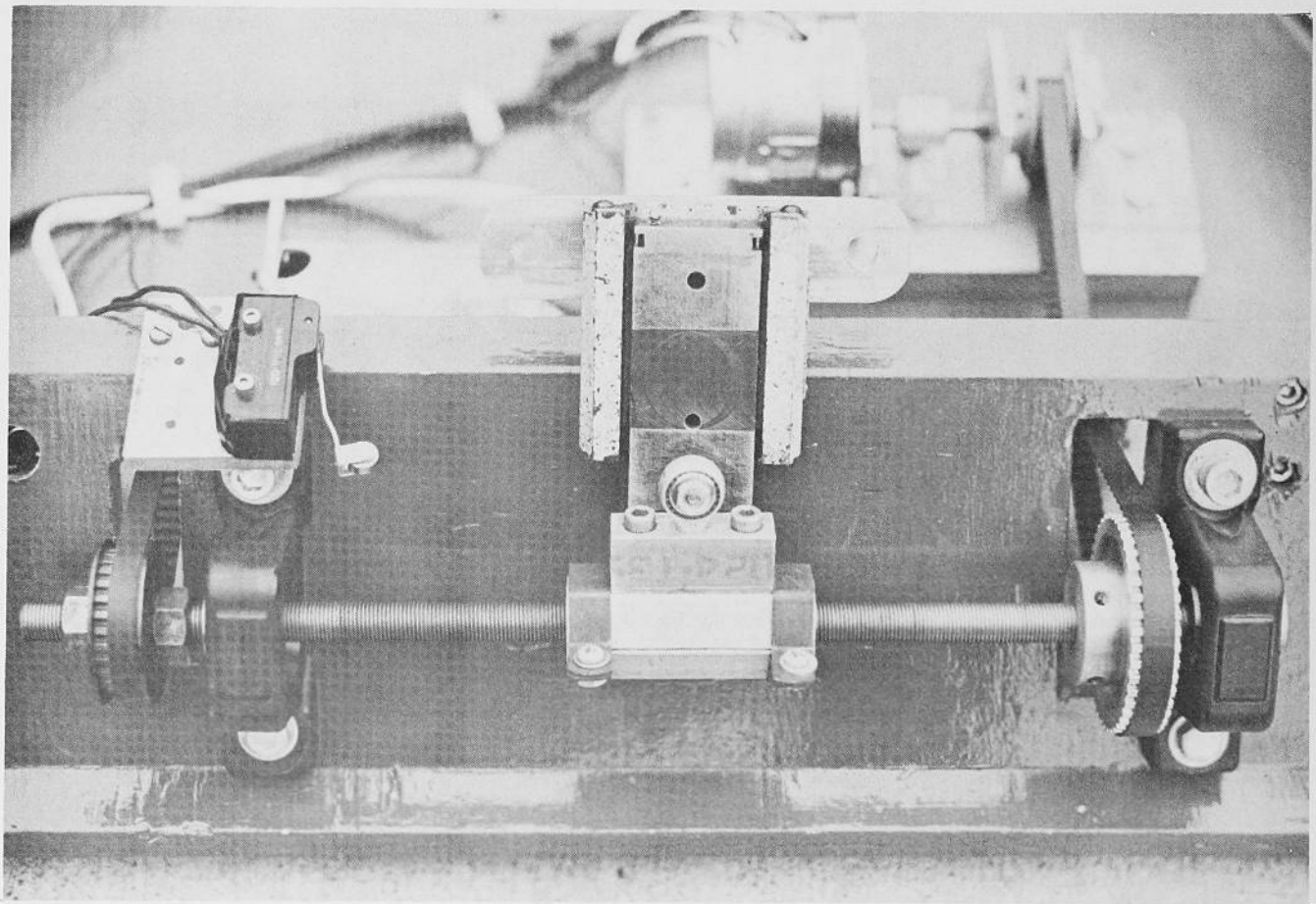
A 3 RPM synchronous motor drives a ½" x 20 stainless steel rod at 1½ RPM via a timing belt and cog gears at a 1:2 gear ratio. The ½" x 20 rod is mounted on two pillow block bearings. Another club member, Gil Machin, made a 3" piece of aluminum hexagon rod into a large nut which is treaded onto the ½" x 20 rod. On top of the nut is connected a spherical rod end bearing, which is attached to a ball slide bearing, which in turn is attached to the upper platform. The spherical rod end bearing allows the linear movement of the upper platform to jointly move without binding. The ball slide bearing allows up and down movements of the upper platform.

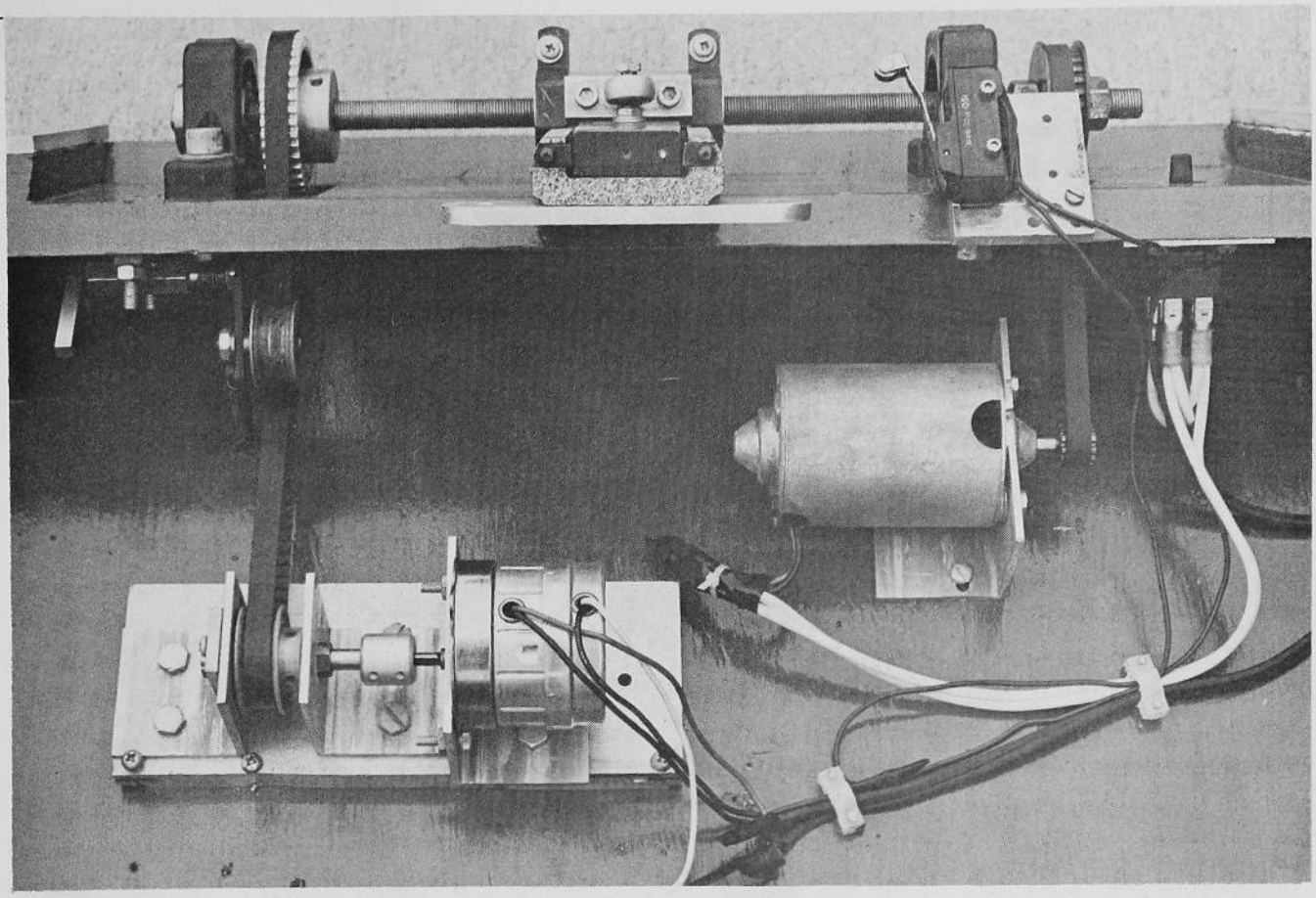
Two more problems of flexure had to be corrected. They were flexure between the ½" x 20 rod and the large nut, and flexure between the nut and the spherical rod end bearing. The flexure was especially noticeable when the telescope was slewed in azimuth. These problems were solved by sawing the nut part way and making two clamps to compress the nut against the ½" x 20

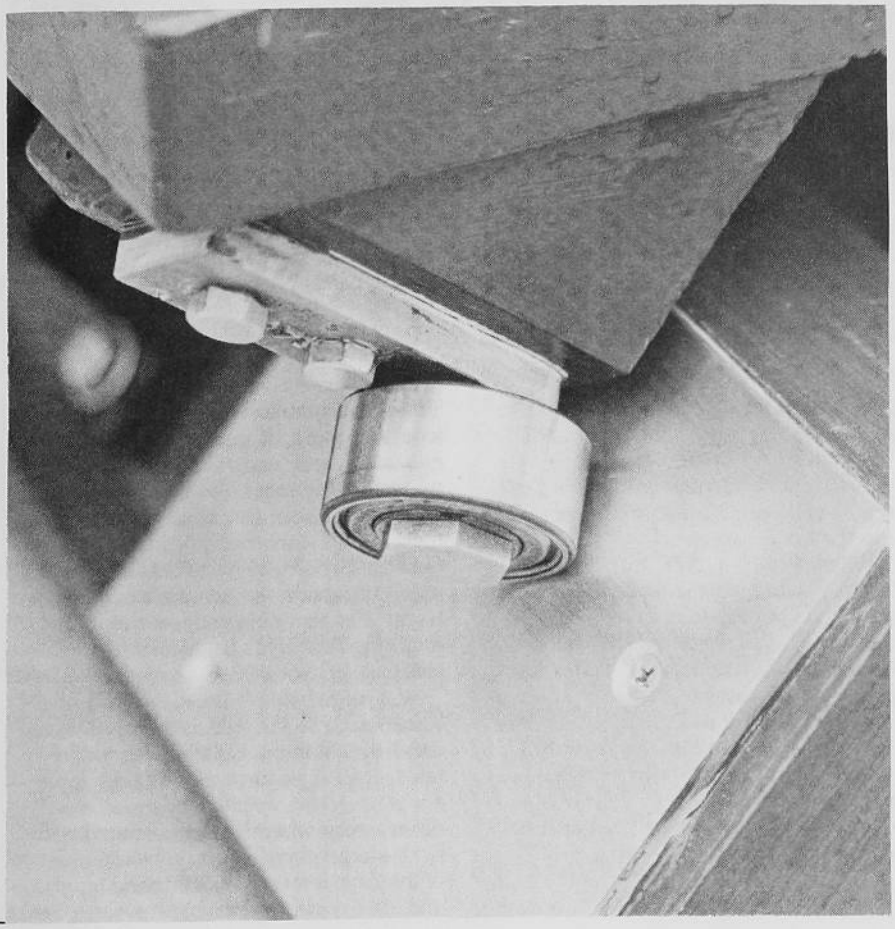












rod. The stem of the spherical rod end bearing was originally only ¼″ thick, causing it to flex. This was strengthened considerably by attaching a small block of aluminum to the top of the large nut. The spherical rod end bearing was then screwed into the block.

The total amount of tracking time is 66 minutes — then one of the legs trips a micro-switch to turn off the drive motor. To reset the Poncet back to the starting point, I disconnected the drive belt from the cog gear by releasing the tension from an idler pulley, then a 12 volt "fast" motor drives the Poncet in reverse back to the starting point in about 10 seconds.

The upper platform pivots on a self-aligning bearing at the south end and rides with two ball-bearing rollers on aluminum plates at the north end.

For visual work, aligning it to the pole has been no problem. I just point it in the general direction of the pole, balance it, place the telescope on top, and start observing.

I would like to thank Gary Ruisinger, Gil Machin, Milton Rose, and A.L. Woods for all the help they have given me on this project.

Tom J. Martinez
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1208 Somerset Court
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Making an Observing Table and Cover for a 10″ Reflector

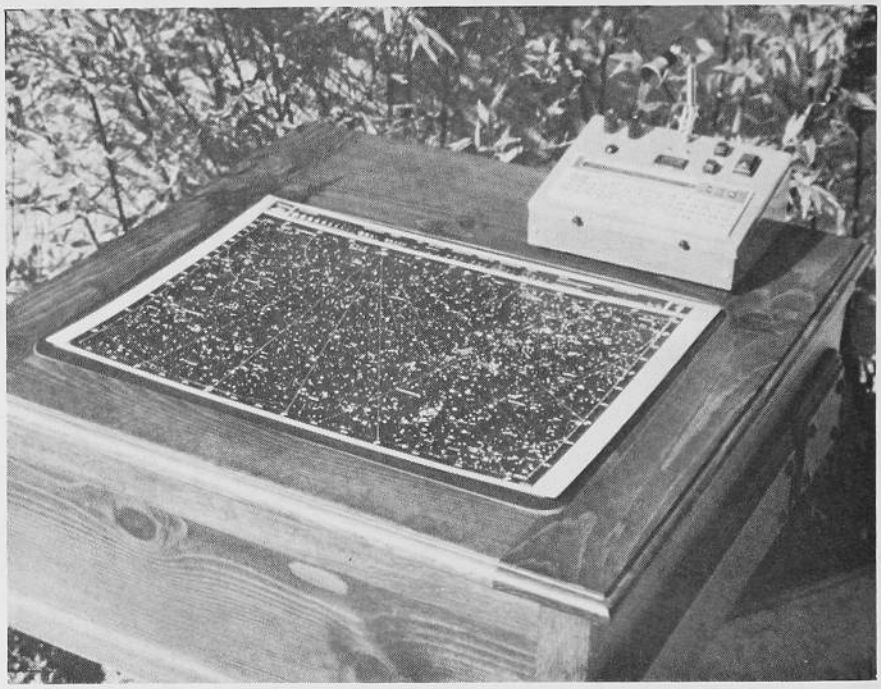
After returning from the 1981 Riverside Telescope Makers' Conference with many new ideas, I spent much of the summer planning and brainstorming. Being new at telescope making and feeling like a real tenderfoot didn't discourage me at all — in fact my first encounter with other ATMs was a very rewarding experience. I must say that I got a lot of helpful advice and encouragement.

A Light Table for Star Maps

However, one thing I noticed was the great number of amateur astronomers and telescope makers fumbling around in the dark with flashlights! As a novice, I wasn't about to harass anyone who shone a light in my face, but I kept thinking there must be a better way. Finally I came up with a solution: I'd build a portable stand with lights that would backlight the star map. In addition, the stand (or cabinet, as it turned out) would double as an accessory table for maps, eyepieces, filters, etc.

I started by making a cabinet 25″ square and 9″ high. The top surface of the cabinet has a cutout area in which a piece of Acrylite "milk glass" plastic fits snugly. On one side of the cabinet are two drawers, one large enough for field edition star maps and another, smaller drawer for accessories. The Acrylite is backlit by six 12-volt flashlight bulbs mounted on a piece of ¼″ plywood. The plywood is fastened to the top of the large drawer and serves as a stop, so the drawer can't spill its contents. The power source is a 12-volt lantern battery which fits in the cabinet behind the smaller drawer.

The whole cabinet sits on a 24″ table base (an obsolete cocktail table from the restaurant where I work) which has a center bolt and allows the table to swivel on a bottom bearing. By the way, plywood on plywood makes a surprisingly smooth bearing surface.



A control panel on top of the table has a red accessory light, which functions to light the pocket microcomputer and 24-hour clock I use for coordinate conversions. Switches for the light table and 12-volt output are also incorporated into the control panel.

When I put a star map over the Acrylite and turn the switch, only the stars and coordinate system light up — the black sky stays dark. This helps me keep my night vision. Another feature is that when the drawers are opened, they are illuminated inside so there is less rummaging around looking for things.

Now that the stand is finished and I've had a chance to use it, I wonder how I ever got along without it. The best thing is that now I'm able to keep everything more organized and have a permanent place to store all my precious astronomical valuables. I don't have to share picnic tables in campsites with my kids any more. If you've ever had hot chocolate and marshmallows smeared on your star maps, you know what I mean.

At home I store the stand in a corner of our family room. It only takes a minute to move it outside — then I'm ready for a night of easy observing without any annoying flashlights to disturb my night vision.

Although the stand could be transported to the field in the trunk of a car, I pack it in our utility trailer with my telescope. A natural place for a table such as this would be in a small observatory where space is limited and light is kept at a minimum. The total cost of the table is less than $100 of materials, and one could probably revamp an

existing cabinet for much less.

Doing It Right

My original plan was to build a quality telescope using the best materials available — but it's difficult sometimes not to compromise on a certain component when something else is more readily available at a better price. I decided from the start that I would not compromise. Already having a good 10" mirror was the deciding factor for the optics, however.

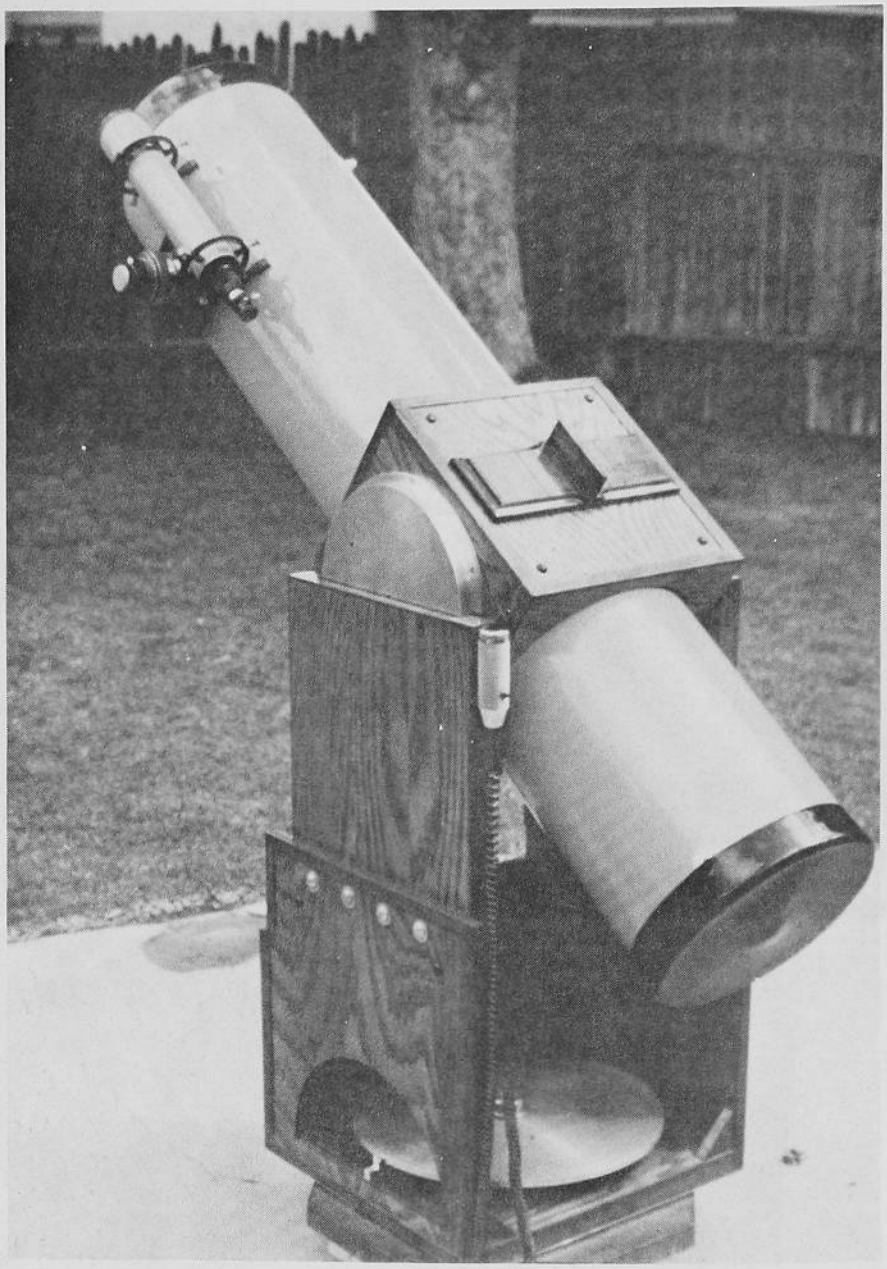
The focuser is an unlikely place to start on a telescope — but since I had purchased a large surplus helical ocular at the RTMC swapmeet, I decided to see if it would function as one. Getting the lens out was a problem — it was frozen solid and nothing would budge it. Finally I covered it with a cloth and hit it with a hammer. "WHAM!" it exploded into a thousand pieces. I was lucky I'd protected my eyes — glass was everywhere, but now the focus mechanism was free.

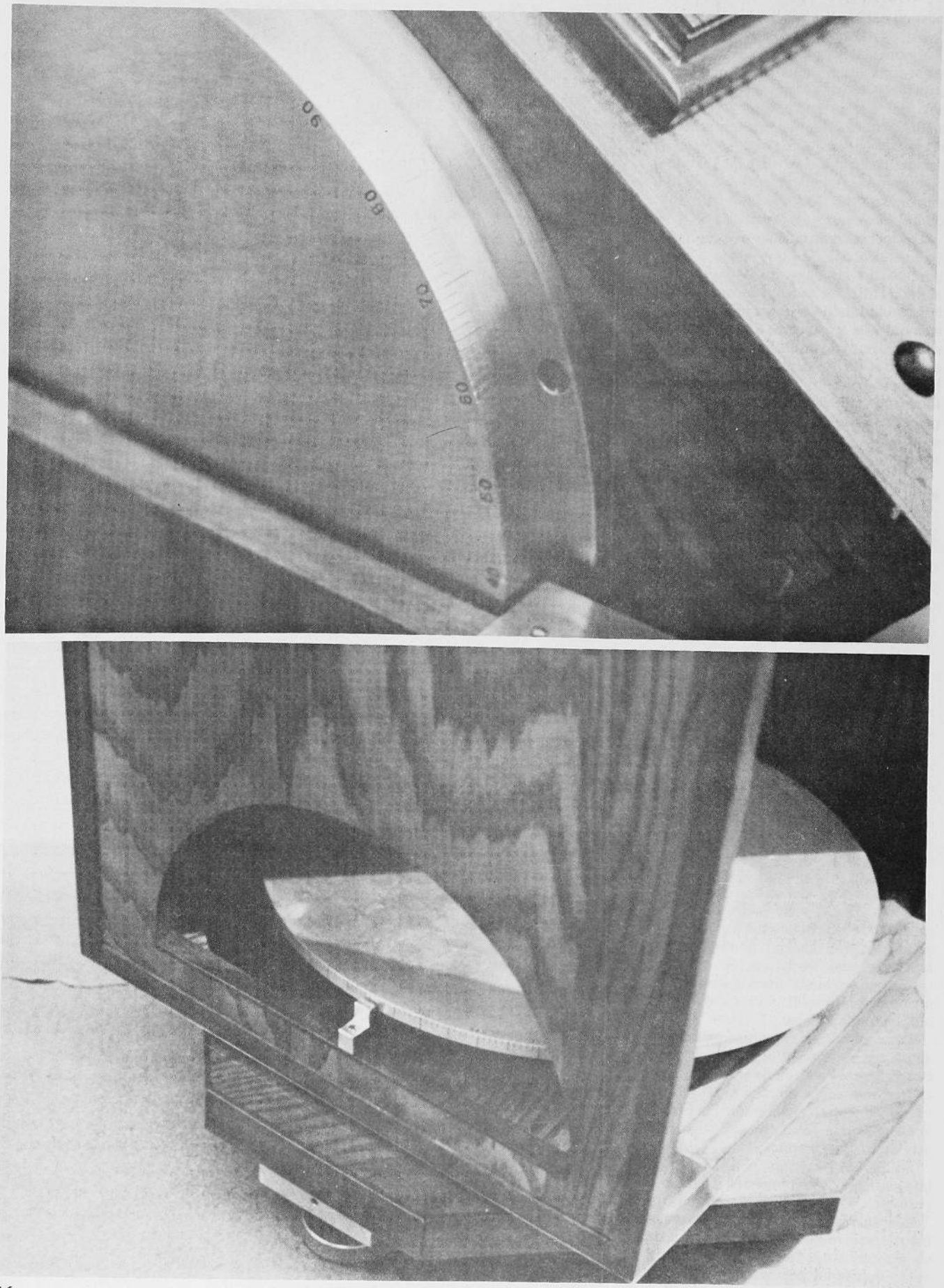
I made a base plate of laminated oak and rosewood. A black plexiglass facing plate was then screwed into the base plate and the ocular was epoxied to it. Getting the World War II vintage paint off the ocular also proved a problem. I used a polishing wheel with bobbing compound to strip it down to the bare brass, then used jeweler's rouge to polish it out. After coating the wood with spar varnish, it was done. Although it's a little heavy, its helical movement functions fine. Personally I am convinced that fast Newtonian systems need a good helical focuser.

Next came the mount. I started with the tube box assembly which is made of ash and trimmed with alder. The rocker assembly is of the same material but the design is a little less traditional, since I cut out a "window" on one side of the cradle boards so that the azimuth setting circle could be viewed with ease. Half of the cradles are enclosed so that the altitude bearings don't shift sideways. The ground board is octagonal and has four adjustable feet instead of three. Why four? Well, four works fine on our stand-up freezer, so I used the same design — in any case, it's solid as a rock and takes only seconds to level.

The center bolt is machined from 1½" aluminum and rises 4" out of the ground board. The azimuth circle attaches to the center bolt with a knurled knob. It was machined from aluminum for me by Bill Schaeffer. He also turned the 12" aluminum side bearings.

The telescope weighs quite a bit (tube box assembly is 78 lbs.), but it is still fairly portable. All the bearing surfaces are Teflon/aluminum and the force to move the scope is rather high, but I find five or six pounds is comfortable for me, and I could change the geometry of the Teflon





pads to lessen it, if desired.

Speaking of Teflon — I found that the shape of the pads makes a difference. Round ones seem to start smoother than square. I also discovered the size of the pads has some effect on the force. A little paraffin wax makes the bearing surfaces run smoother and prevents metal burrs or dirt from digging into the Teflon. I realize that these suggestions seem to go against the usually accepted practice, but they all work.

One of the embarrassing things that happens sooner later, I am sure, to most TMs is drilling a hole in the wrong spot. Although I went through great pains to measure the optical path and get an exact focal length before drilling the hole in my fiberlite tube, forgetting to tell my wife where to hold the tape measure caused a lot of grief and anguish.

Somwhat to my surprise, however, I found repairing a telescope tube isn't very hard. I used "Devcon" liquid metal to replace the disk I had cut out. After a little filing, sanding, and a new paint job, the tube looks like new.

There are many types of paint on the market. After talking with a few people "in the know" about paint, I kept getting the same answer: Dupont's Emeron. It won't crack, chip, fade, or peel, and supposedly it can be hit with a hammer and not leave a mark. Whoa, I don't think I'll try it — it costs over $100 a gallon.

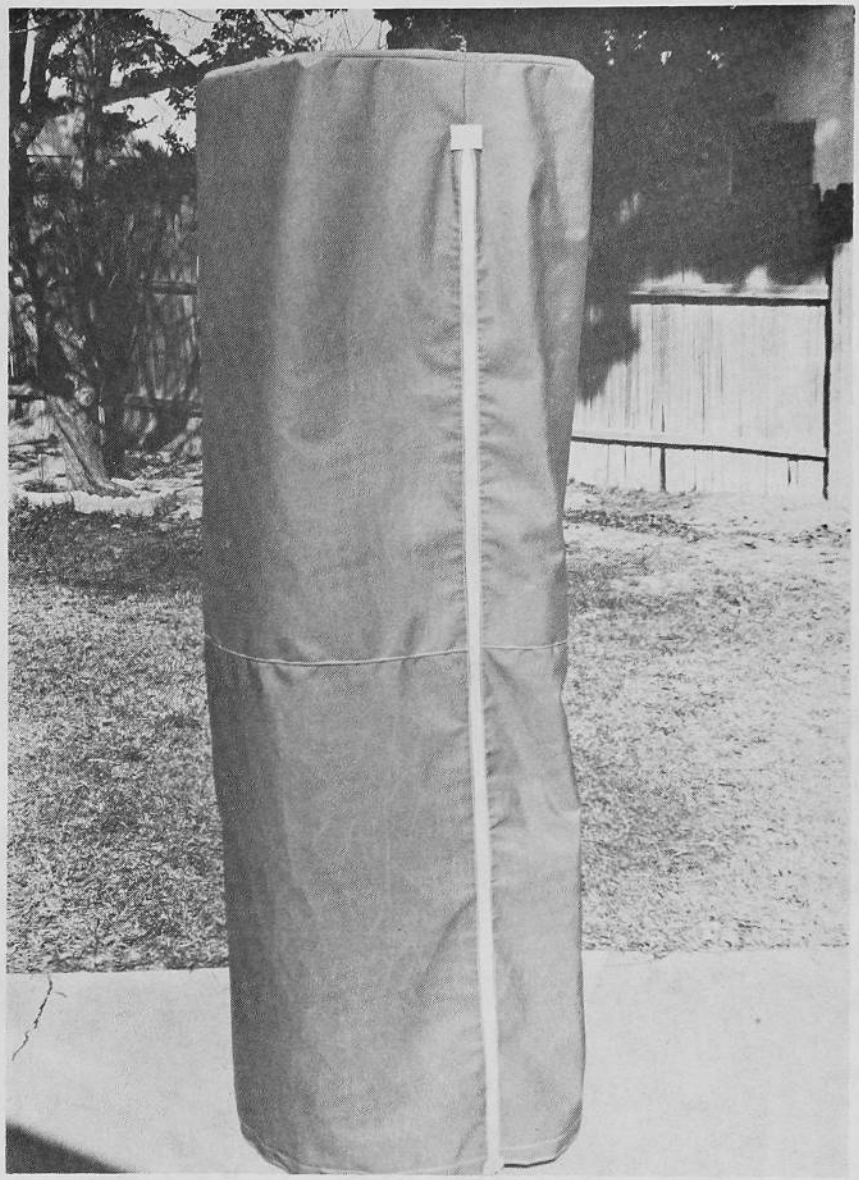
But a telescope tube needs less than a pint. Some auto body shops that specialize in custom paint jobs have it in stock — and the novelty of painting a telescope can usually lower the price some, especially if you promise to let the guys in the shop look through your scope.

The finishing touch on my scope is a polar sundial. It is mounted on the tube box, and when the tube is properly oriented to the celestial pole, the dial reads apparent solar time to within a few minutes. So big deal! Who needs a sundial on a telescope? Well, working backwards, if you know the apparent solar time and your latitude, you turn the tube to read the proper time. Now the azimuth circle is properly set at zero. If conditions are good, the brighter stars and planets can be located during the day with the setting circles.

For practical purposes, it's turned out to require too much guesswork to be really useful — but I enjoy it and it's great fun to show kids how to tell time by the Sun. They're always so amazed. The most common remark is, "How do you make it do that?"

Making a Telescope Cover

Observing in the early morning hours when I arrive home from work is very relaxing. The trouble is that when I really want to observe I'm too lazy to go through the hassle of setting everything up, especially knowing that I'll have to put it all away again before going to bed. What a discouraging prospect after a night's work! What I need is a backyard observatory, but aside from not having the available space or funds, an observatory seems a bit extravagant when all I own is a 10-inch Dobsonian.



But what good is a telescope you don't use?

Finally I decided that what I really needed was a cover — something to protect the scope from dew and dust. For a while I used a cheap sleeping bag. It worked rather well except that it wasn't waterproof and didn't zip all the way down. I had to keep a constant eye on the weather and hope that a storm front didn't roll in while I was at work.

Upon completion of my new telescope, it became apparent that I had to find a better way to keep things set up — or I'd soon find myself spending less time observing. So I went to see a guy who made boat covers and ski bags. He gave me an estimate on a telescope cover, and the price was right. I gave him dimensions and a deposit, and a week later picked up the cover.

Things are much easier now, and I observe every chance I get. The scope is still put away during inclement weather, but in southern California rain isn't really a big problem.

A few years ago while on a camping trip to the Grand Canyon, we encoutered some bad weather. Violent winds and blowing snow caused me considerable concern about leaving the telescope outside to fend for itself. Although no damage was done, I feel more relaxed about those situations now that I have a cover.

Stephen K. Kysor
11782 Bluejay Lane
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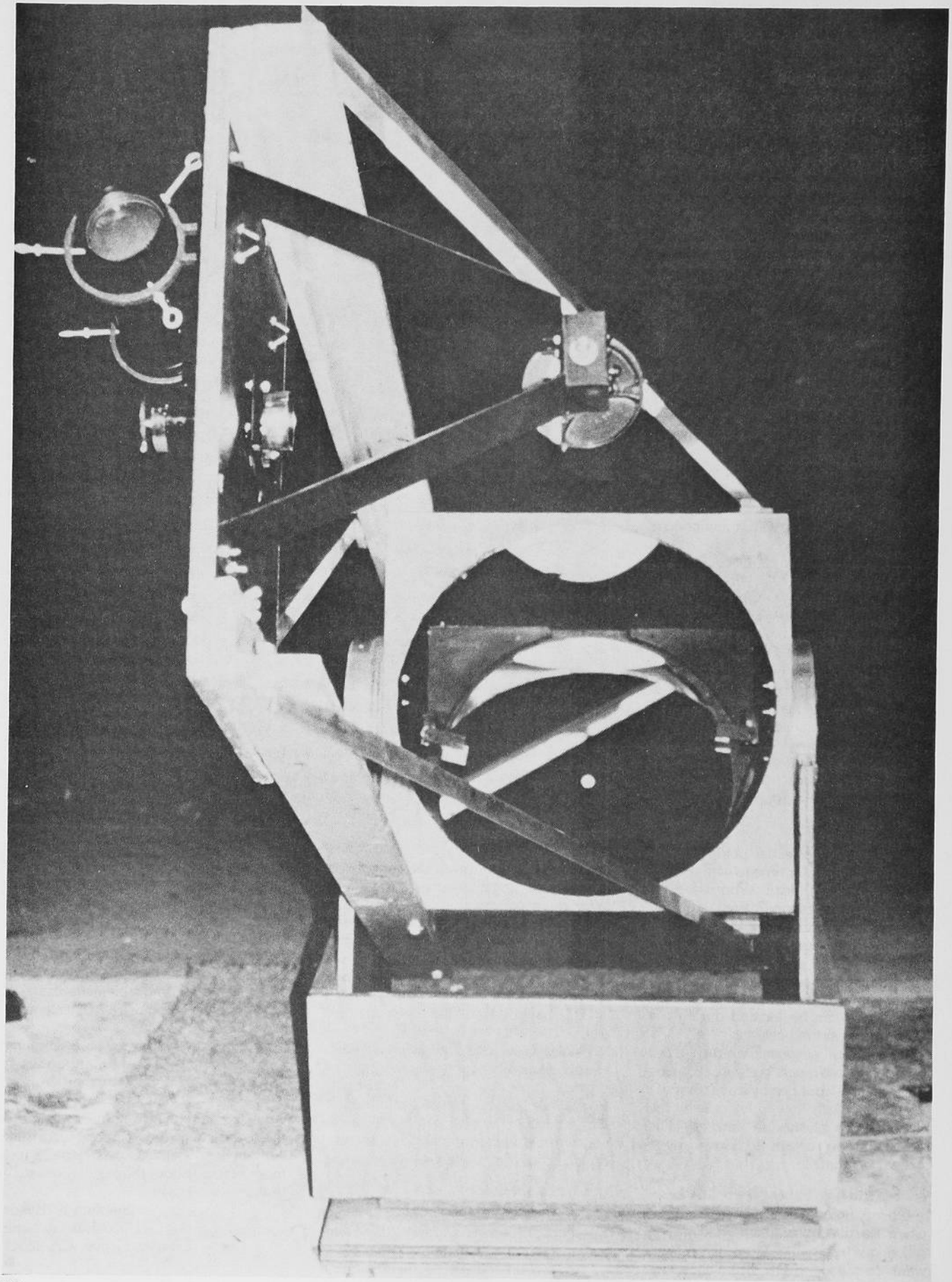


An Easy Design for a Truly Portable 17.5″ Reflector

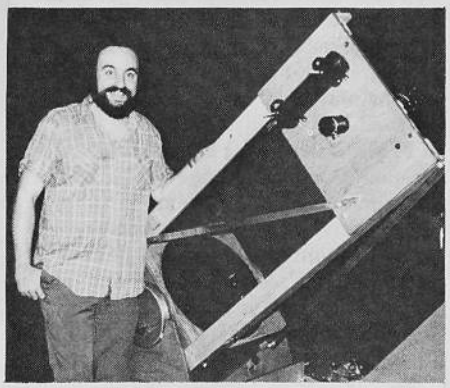
This is the telescope for all those people who ordered a set of Coulter's 17.5″ optics — in a fit of weakness, no doubt — and when they received them just couldn't believe how *big* 17.5 inches really is. And since this is an article about telescope making, it probably should appear in *Telescope Making*. However, its purpose is not to reach dyed-in-the-wool telescope builders, but instead to reach people who own their optics *but haven't yet done anything with them*.

We suspect that the readers of TM do not, for the most part, fall into this class, or that if you haven't yet built the telescope, it's for lack of time or money to do the job the way you want to do it. We hope, therefore, that if you, as a TM reader, know someone who is sitting on a set of big optics trying to work up the courage to build the telescope, you'll show him this article. Photocopy it for him. Press it into his hands. Urge him to get on with the job undone.

This design is a compact version of what is usually a monster telescope. It can be transported in a small hatchback car with camping equipment and other riders. It is a design for people who are more interested in observing convenience than looks (this telescope is ugly) and who don't own more than a saber saw and a drill to build it. We think that the 17.5″ is the most common large aperture instrument because it is commercially produced, but this design will work with anything that is big.

It came about because late last summer, Tom Burns got the chance to travel to some dark-sky country for his vacation. He wanted to take his 17.5″ but saw that the problem of transporting it was too great. At that time he had his 17.5″ conventionally mounted, Dobsonian style, in a piece of Sonotube. It was such a huge instrument that people at the Richland Astronomical Society were known to nudge their little telescopes up against it in the hope that they would "suckle and grow up."

So he had just about resigned himself to making do on his vacation with his "12" even though the thought of all that aperture left behind just about brought a tear to his eye. It was then that we decided to redesign his telescope. At issue here is an important, but obscure,



principle: you must be careful when remaking a telescope, and extremely careful when trying to reduce the size of the instrument, or else you'll be forced into a series of compromises that will leave you a couple hundred dollars poorer and with a telescope exactly as difficult to move as before. Telescopes are like avalanches in this respect: it doesn't matter whether you throw a pebble or a boulder off the mountainside, the same number of tons reach the bottom.

It was obvious (in retrospect) that the place to save weight and bulk is in the tube, because the tube must be supported by the rocker, and a lightened tube means a lightened rocker means a lightened baseboard. And the best way to save weight and bulk in the tube is to not *have* one. Thus, the balance point of your non-existent tube is way down near the mirror, resulting in a further reduction of the size of the rocker. And, of course, the non-tube is easy to not-load into the car.

Now, even an idiot knows that you can't get rid of the whole tube because you have to have something that holds the diagonal and focuser. But a lot of the tube in most telescopes simply occupies space, and you can get rid of most of it as long as you are careful not to cut away the strength.

Because we didn't have a great deal of time, we were forced to steal mercilessly from other telescope makers — so we will try to make it up to them by giving them credit. We liked Thane Bopp's "tube" design, which was depicted in TM#17, page 14, and *S&T*, August 1982. Differences in our design include a triangular spider, a stiffening board placed at the top of the mirror box, and non-folding sideboards. Another difference, we thought, was our inclusion of side braces. But it turned out that Mr. Bopp had side braces too, and the photographer had taken a picture of an incompletely assembled telescope, proving once again that great minds think alike!

As a friend, Doug Wereb of Leander McCormick Observatory, pointed out that this tube assembly is nothing more than a reincarnation of the old "sky beam" mounting. "Sky beams" were more common in the 1930s, and they litter the pages of *Amateur Telescope Making Book 1*. For those who have not heard of it, these instruments were "a telescope on a stick," where everything was mounted sideways on a piece of wood (more than likely a 2x4). The mirrors of these things seldom got bigger than 6″ though. When you attempt to mount a 17.5″ mirror that way, you can no longer rely on the natural strength of wood, and you have

to "design some strength in," hence the braces and stiffening boards.

Although we liked Mr. Bopp's tube design, we were less enthusiastic about his outboard pipe mounting because we didn't think we could make it work in time for Tom's vacation. We chose the inboard Dobsonian design because Tom has had a great deal of experience with it.

A rocker that can be bolted together and taken apart was made by Rick Shaffer and Dana Patchic and shown at Riverside, and we modeled our rocker after that. Our version is much smaller and lighter, however.

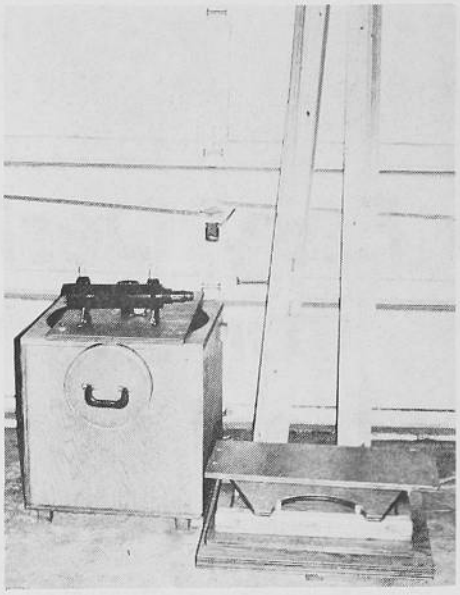
We will not give detailed drawings and plans of this telescope. You folks are smart enough to figure out how to make it. What we will talk about are things that aren't too obvious.

Baffles: A Newtonian with a tube is automatically baffled against incoming spurious light (unless the tube is too short) and so most telescope makers don't encounter baffling until they try to make a refractor or a Cassegrain.

What we must baffle out is direct light coming in past the diagonal — general sky light, little red flashlights, distant streetlights, etc. The best way of baffling this light out is a circular disk of cardboard (or some other light material) mounted behind the diagonal. For use, one of eight-inch diameter was found to be adequate, and we wouldn't really want one much bigger than that. We are sure that some of you are recoiling in horror at putting an eight-inch disk in front of the mirror (even sideways), for fear that it might cause a lot of diffraction. All we can say is that it causes roughly the same diffraction as each of the beefy spider vanes, which is noticeable only on the brightest stars. One note on the baffle's installation: rack your eyepiece really far out of focus on a bright star to verify that you've got it truly perpendicular to the mirror. You may have to bend it some.

One mistake you can make is to mount the eyepiece right down against the imaginary tube with a short focus travel. What is generally a good move with conventional Newtonians becomes a serious error with this one. This is because your focuser tube is part of your baffling. A long focuser tube keeps the baffle disk small. We found that the Meade 2″ focuser worked fine, for example.

Mirror Box: We feel that the greatest advantage to this telescope besides saving weight is its handling of the mirror. You load it from the front, and therefore you don't have to build a hinged rear. Once loaded, it stays that way. You're not forever handling $700 worth of glass in the dark, fingerprinting it at best, dropping it at worst. The



bottom box has a second purpose — it serves as a mirror cabinet for permanent storage of both of the mirrors. The diagonal section goes down into the top of the box and a plastic bag goes over that. You must be sure that the mirror box will go into your car, so before you even attempt this project, measure your car. The box, plus what it stands on (little feet in our case), plus the height of a fully-racked focuser must get inside the narrowest portion of the car's door (or hatchback). Your mirror box should measure about 19 inches square and be approximately 20 inches high. It should be made of ¾″ plywood.

Front Stiffening Board: The ring-shaped front stiffening board is not optional, as the similar structural element is on tubed Dobsonians. It virtually eliminates torsional flexure. If you "grab one rail and push it and grab the other and pull it," the whole instrument will twist if this flexure is not eliminated. Flexure creates backlash in the azimuthal motion. While the board is necessary, it needn't be as thick as the rest of the mounting. One-half inch should be sufficient.

Rails: A side rail is made by gluing-and-screwing two 1x3 pieces of real wood (i.e., not plywood) to make an L-shaped piece of "wooden angle-iron." Cut them a little long. You make corrections to miscalculations in focus position by moving the entire diagonal mounting board up or down the rails, and you want to have a little extra just in case. After you've found focus and verified that it's okay, they can be cut to length. (Carefully select the wood that you will use in these rails; if you don't, you may get warped rails. Even if they are a bit warped, you may be able to force then into space and use your telescope anyway.)

The rail is attached non-permanently to the box by four staggered bolts that either screw into threaded metal inserts (T-nuts) or, less adviseably, tighten on the outside with wing nuts. Note that I said outside. Even though you can save some room by putting the wing nuts on the inside, you will eventually drop one of them and hear that fingernails-on-blackboard noise as a piece of hardware skitters across the mirror. This sound takes years away from your life. (Perhaps, like us, you'll want extra mirror protection, so you'll take the big useless round piece you sawed from the front stiffening board and set it on blocks just above the mirror.)

One other note about these screws: when in place, they stick out the side of the mirror box and add width to the tube assembly. Don't forget them when you are making your plans for the rocker. We almost did and came perilously close to wasting a lot of plywood.

Rocker: The rocker was made of ¾″

plywood, which was braced by 2x2s, nailed and glued. In the 2x2s were drilled holes through which bolts threaded into T-nuts. The side boards bolt to the bottom of the rocker, and then the front board is bolted to the side board. Those of you for whom car space isn't such a big deal (i.e., for those who don't plan to pack half of their total belongings and tents to house everything) might want to build a conventional rocker that won't come apart, as we did for the 16″ telescope also pictured in this article.

Side Braces: The side braces are made out of common light aluminum angles that are available at nearly any hardware store. The only thing you have to be careful of when installing them is the size of the holes you drill in them. These holes must be precisely the diameter of the screw that you will put in them. If you put on loose side braces, they won't do you any good.

Other materials will probably serve for use in these braces. We used aluminum because the shiny finish reminds us of the chrome on little sporty cars. Besides, it doesn't weigh much.

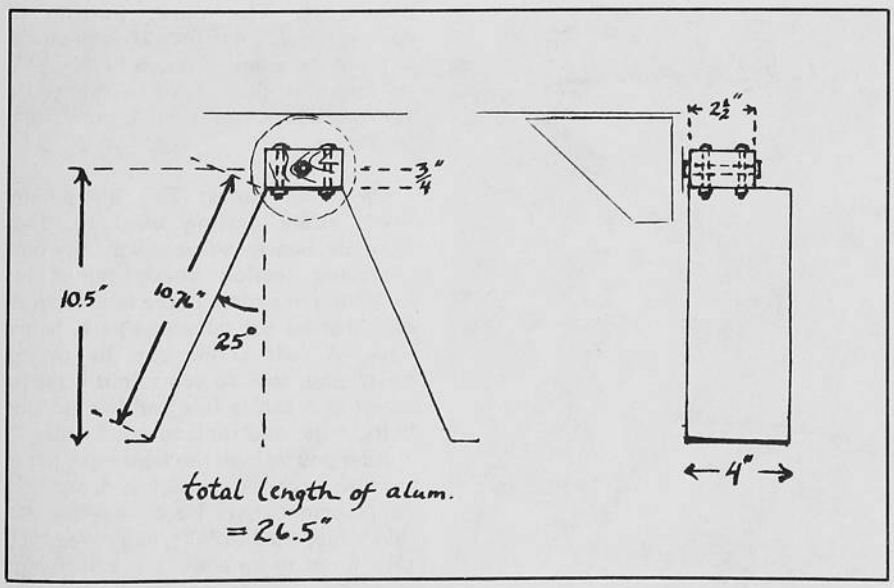
Diagonal/Focuser Board: This board is all that is left of the tattered memory of our tube. We have placed the focuser and finder on one side and the spider and diagonal on the other. It is a sobering experience to hold that light board with hardware attached and realize that you have all the necessary elements of the upper half of a 17.5″ telescope.

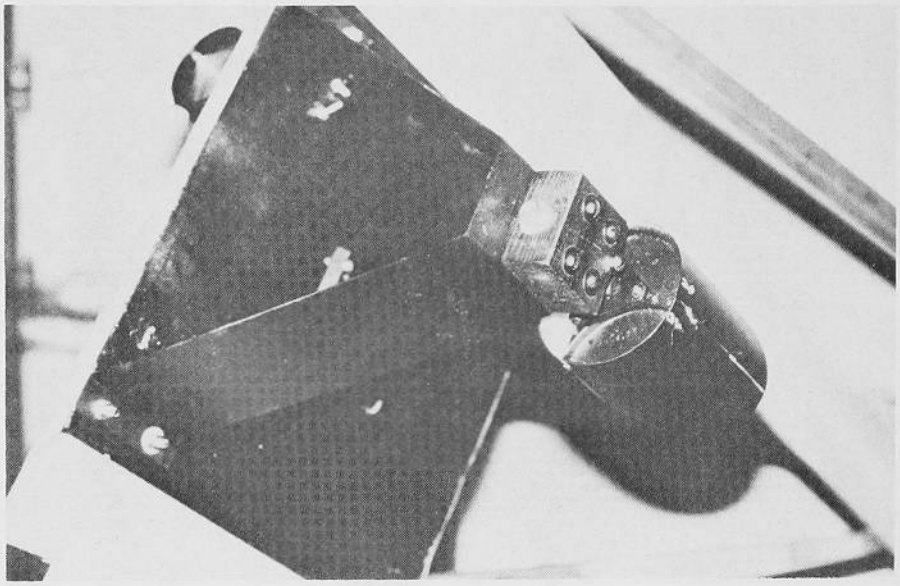
It is important to remember that any weight you can get rid of up here close to the end of the telescope pays for itself many times over at the bottom. Therefore, you should choose light materials. Since many of the pieces of hardware have a fixed, non-changeable weight, probably the only thing you can change is the board itself. It should be thin and not very long. The 17.5″ here has a much too large diagonal-focuser board; it is ¾″ thick and nearly as long as it is wide. The 16″ telescope has a much lighter design; it is only ¼″ thick and a foot long. The ¼″ board is unacceptably flexible, so we reinforced it with (what else) some of that sexy aluminum angle.

Spider: The spider is one which must hold a 4.25″ minor-axis diagonal straight without the benefit of a tube to hold onto. It must be made of metal and have vanes that are unusually wide. For this telescope we chose a width of 4″ and aluminum metal, 1/16″ thick, but you could probably get away with 3½″ and .050″. The block into which the diagonal holder is inserted is made of wood and is held to the aluminum spider by four ¼″x20 bolts. The block of wood is somewhat shorter than 4″ to accommodate the bolt at the rear of a Novak diagonal holder (see figure).

You'll need some way of bending aluminum sheet nicely (you don't need instructions to bend it "not nicely"), so we'll give you one method. You start with a long piece of aluminum 3.5 or 4 inches wide and make scribe marks where you want it to bend. Then you find a table or workbench with a straight up-and-down edge rather than a rounded edge, and lay the sheet of metal down with the scribe mark barely off the edge of the table. Then you take a piece of scrap aluminum angle (or something more substantial if you've got it) and clamp it on top of the sheet with the vertical part of the angle just off the scribe mark. The aluminum is now firmly sandwiched between a piece of angle and the table, held by two C-clamps, with the portion to be bent sticking out.

Now you take the end of a 2x4 and bend the sheet down against the table.



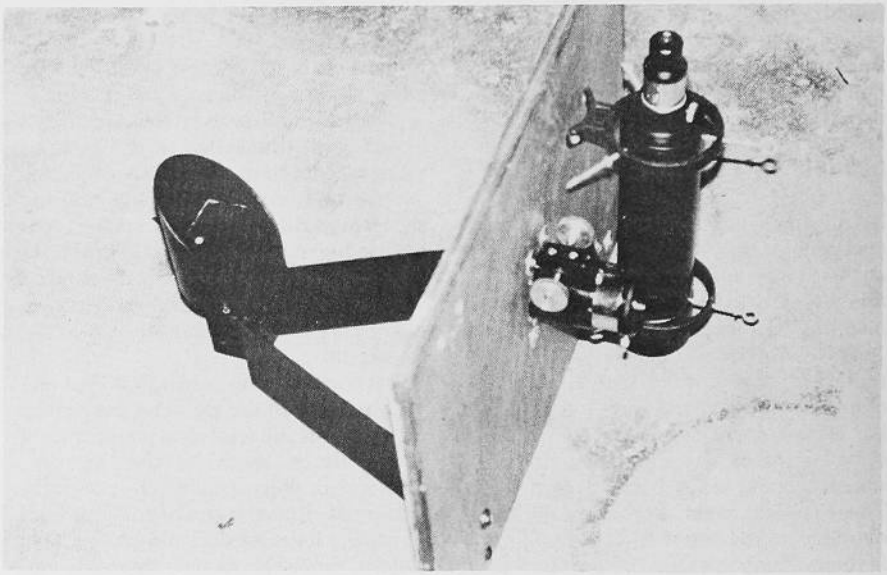


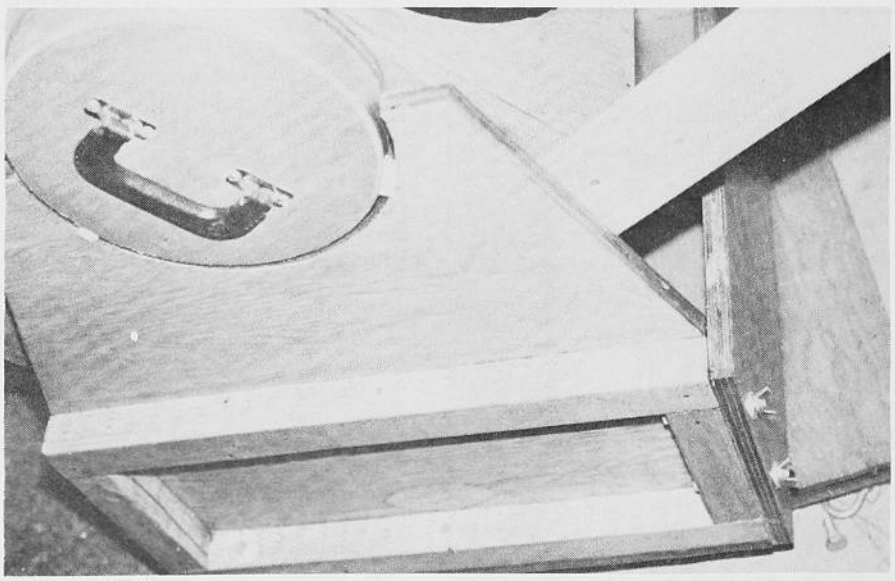
Pretend that the amount of aluminum sticking out is only ½". Bend just that imaginary ½" and the rest will take care of itself. Bending a 1/16" sheet takes a great deal of force, so this will probably be the most difficult task associated with building this telescope. You might want to experiment with homemade hinged bending tools to do this job right.

Occasionally, the bending will not go well, or the angles shown in the figure will not be precisely reproduced. Don't worry about it; the spider can be "experimentally" placed by looking in the focuser tube. Even if you mess that up, shims or washers can save it.

Bearings: Because this instrument balances so close to one end, it is very sensitive to changes in weight (like using a different eyepiece). Therefore, the altitude bearings must be made large so they can supply the necessary frictional torque. If you think you can get by with those undersized bearings you robbed from your 8" telescope, forget it. You won't. Bearings such as we used, 10" diameter, are the minimum size.

Balancing: As long as we are on the subject, we should discuss the topic of balancing. You should balance the "tube" before building the rocker (so you'll know how tall to make it), and you should balance the instrument for the heaviest weight it is likely to carry (time to dig out that 2.1" solid "brass and glass" surplus eyepiece). You must have everything on the telescope: the eyepiece, the finder, the finder's eyepiece, the diagonal, the side braces, and don't forget the mirror. String a rope under the front end of the mirror box and try to lift the horizontal telescope (get a couple of your friends to help you). Most likely it will be front or back heavy. Scoot the rope and try again. If you must make an error, try to make it in the direction of back



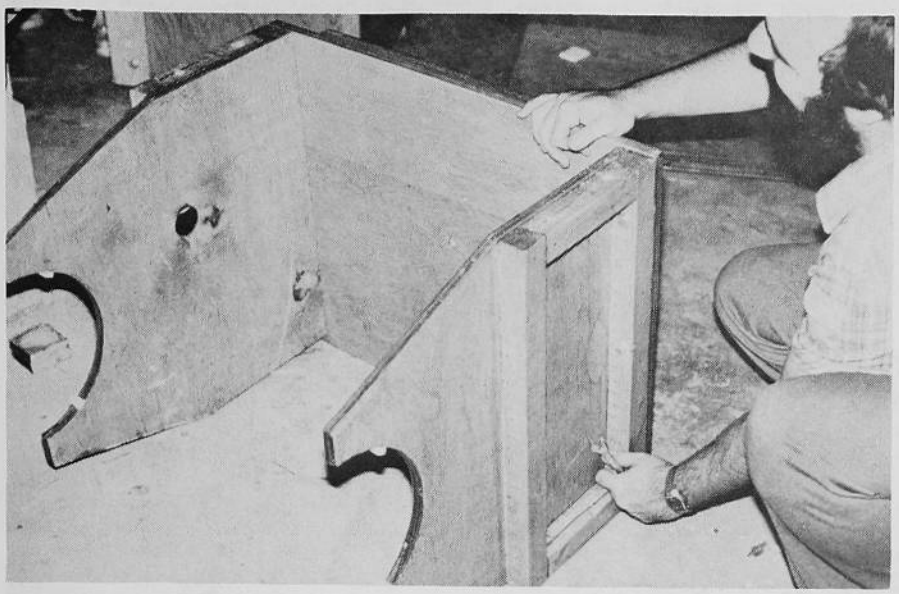


heaviness. The cure, putting a comparatively small weight on the front of the instrument, is much better than the huge quantities of dead weight you'll have to add to the rear to cure front heaviness.

* * * * *

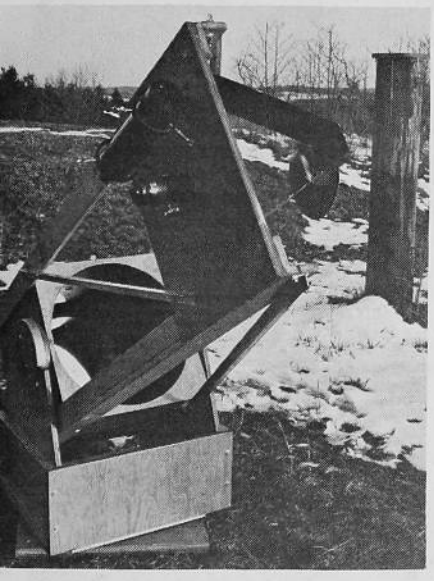
Operating Notes: This instrument takes some getting used to. For example, nearly everyone will have one observing session utterly ruined by forgetting one piece of the telescope. A checklist for the telescope parts helps here. A lost screw can be pretty frustrating, too, so you might want to invest in a tackle box and lay out the bolts, nuts, and tools in good order.

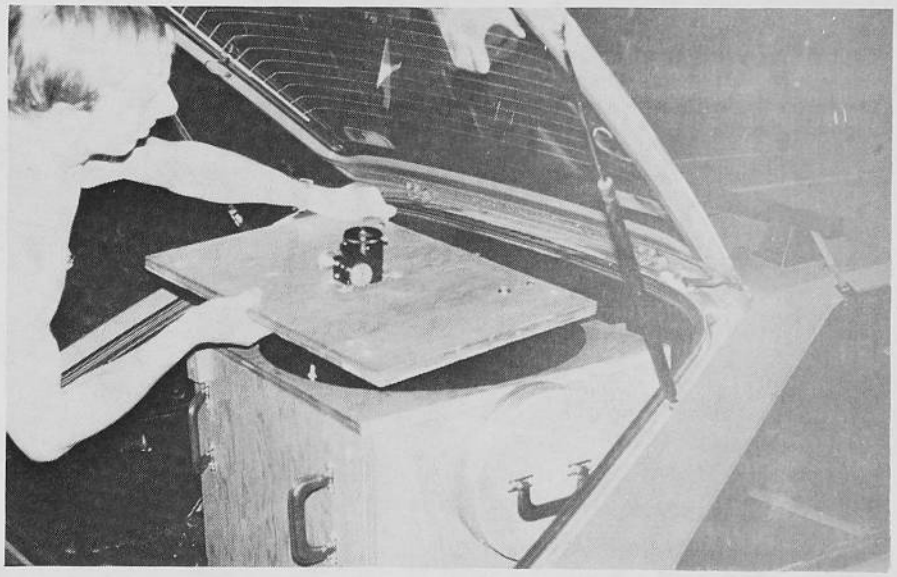
After you've built the telescope, put it together once in your backyard, and had fun playing with it ("Hey! I'm where the tube's supposed to be!"), you're ready to take it out to do some real observing.

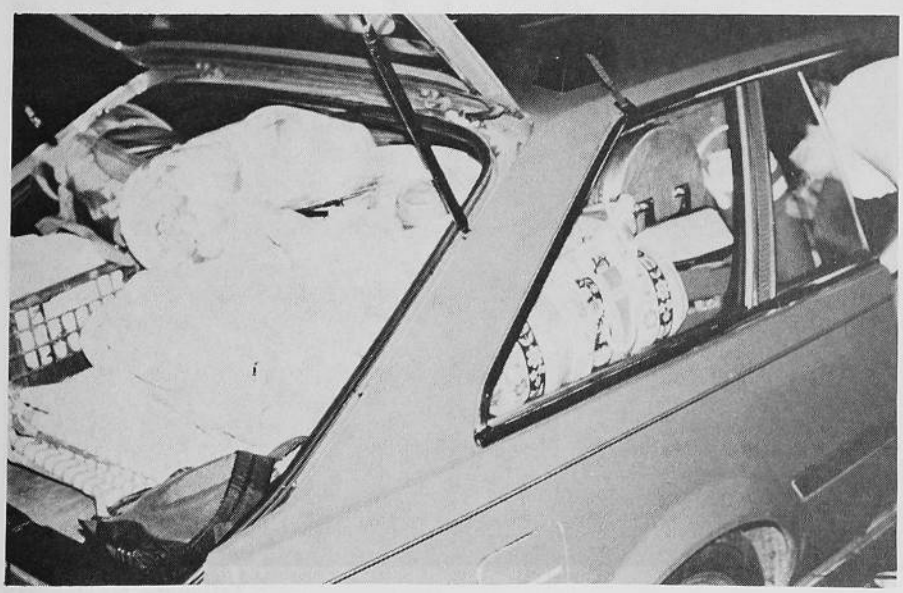


Knock it down, fold it up, slide it into the car. Typical hatch-back auto capacity: 1 17.5" "Boppian" Reflector plus 1 Ton camping gear.

In loading the car, you first decide whether you'll leave the rocker assembled. That is usually the case, so you put it in first, front down. Then you slide the mirror box inside of it, and load all the other junk. The rails are strapped to the top of the car (top carriers are available at Sears). You must be careful not to let them stick out over the rear,



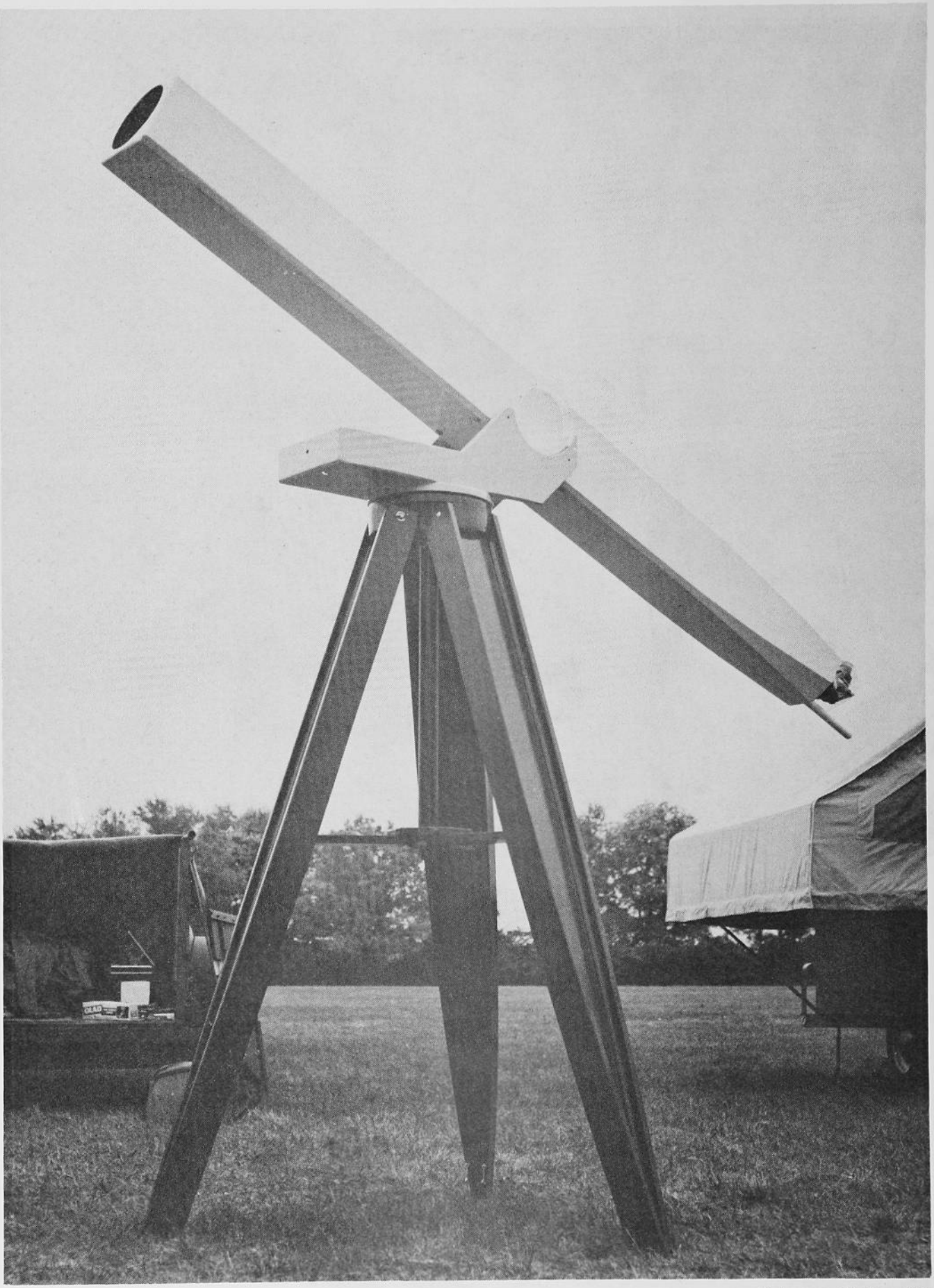


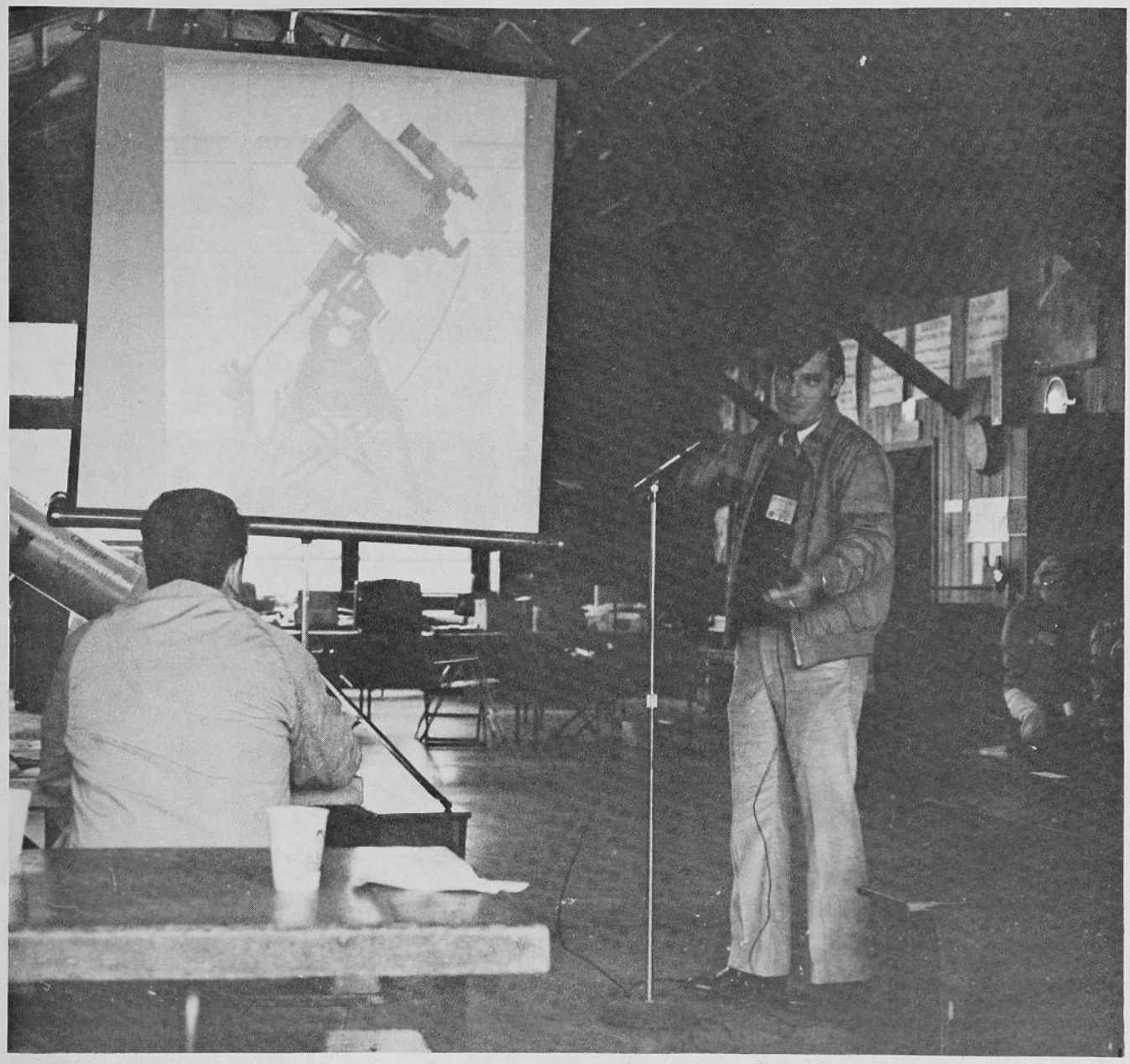


as that is illegal in most states. Leave the side braces attached at one end to the rails. Finally, circle the car three times to look for the telescope parts that you carried to the car, checked off the list, but forgot to load *in* the car.

It is not until you are under way that it finally hits you. You look around the car, and see that it is essentially empty. You think, "I'm carrying a 17.5-inch telescope in an empty car." You look over at your observing partner, who is insanely happy not to have to make the trip scrunched up astraddle the tube. And finally you look up at the clear blue sky, expecting the lighting bolt that comes to all those who have gotten away with what you have done.

Dick Suiter and Tom Burns
240-C W. 8th Ave.
Columbus, OH 43201

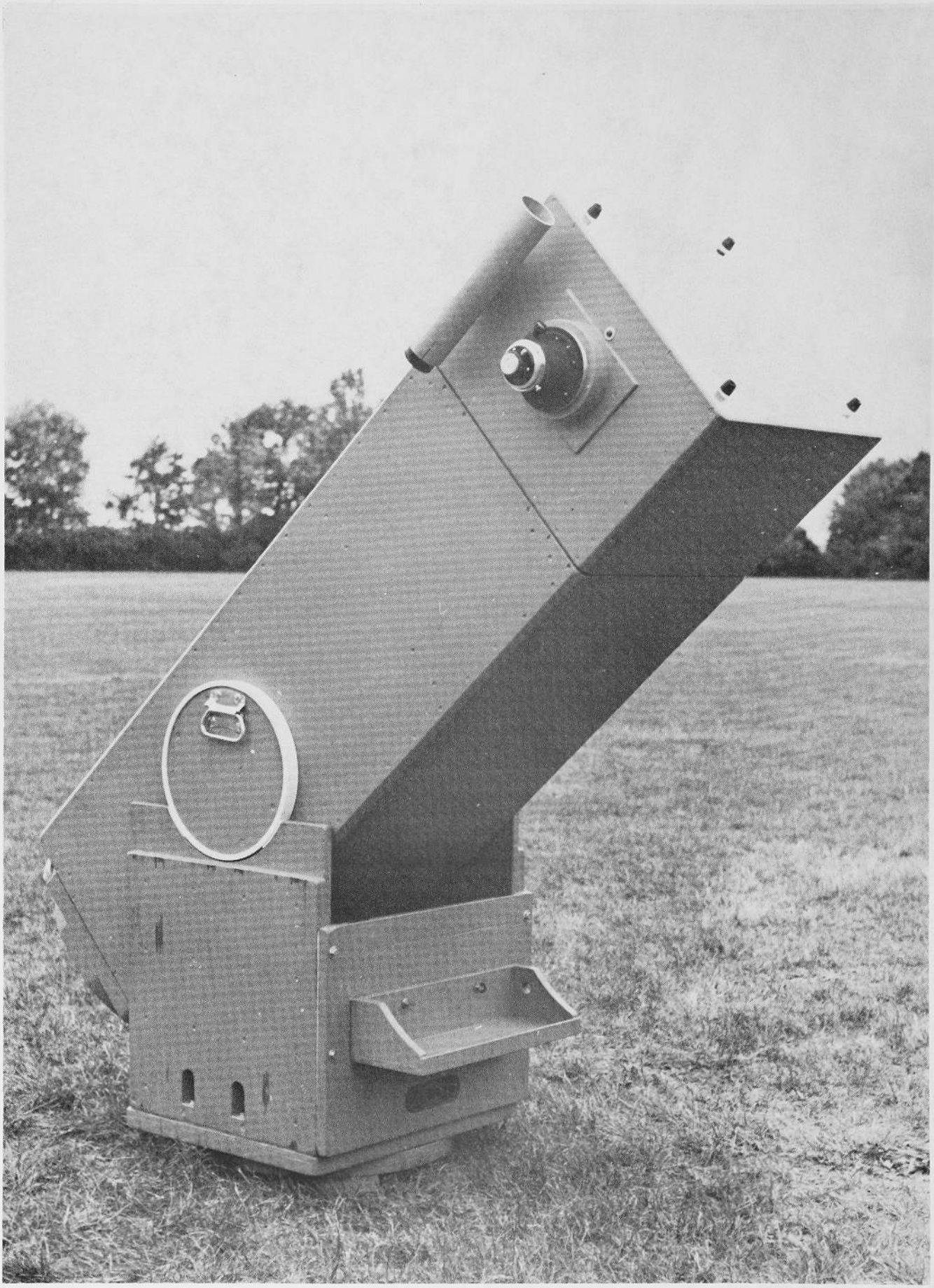




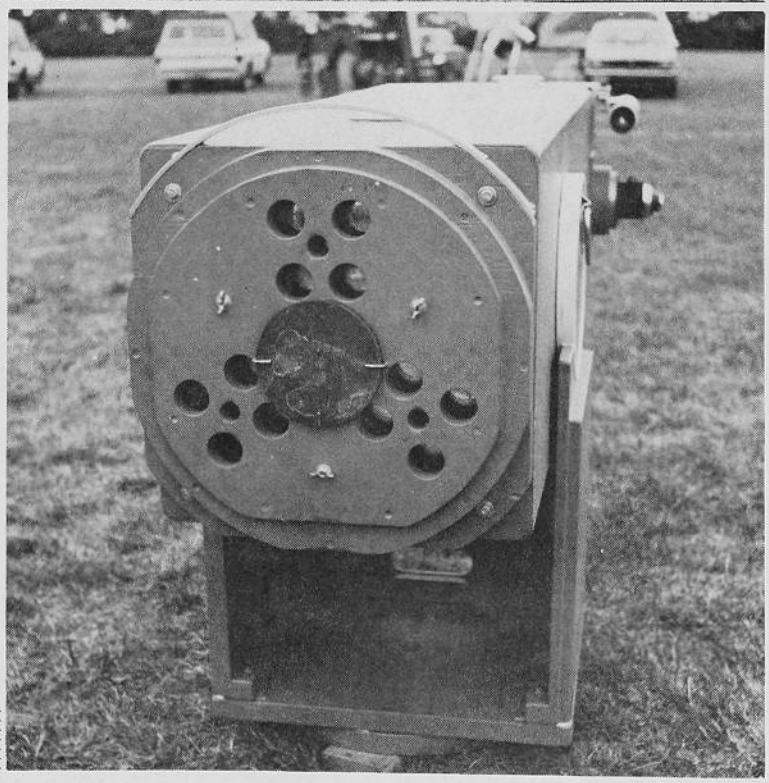
ASTROFEST 1982

Left: The secret of making a tripod really sturdy seems to be bracing the top from rocking. In this case, a central 1½″ steel pipe stabilizes the head; the pipe is restrained by braces from the middle of each leg. The braces are unbolted and folded against the leg; the tripod then folds, each leg locking into a boss on the bottom end of the pipe. Each leg is an "H" section made from two 1x4s and a 1x6 #2 common pine board. The hub at top is built up from four layers of ¾″ plywood, and is 12″ in diameter. The telescope tube is ¼″ plywood. It is 8″ square, 102″ long. The 6″ f/15 objective is inset 12″ from the upper end.

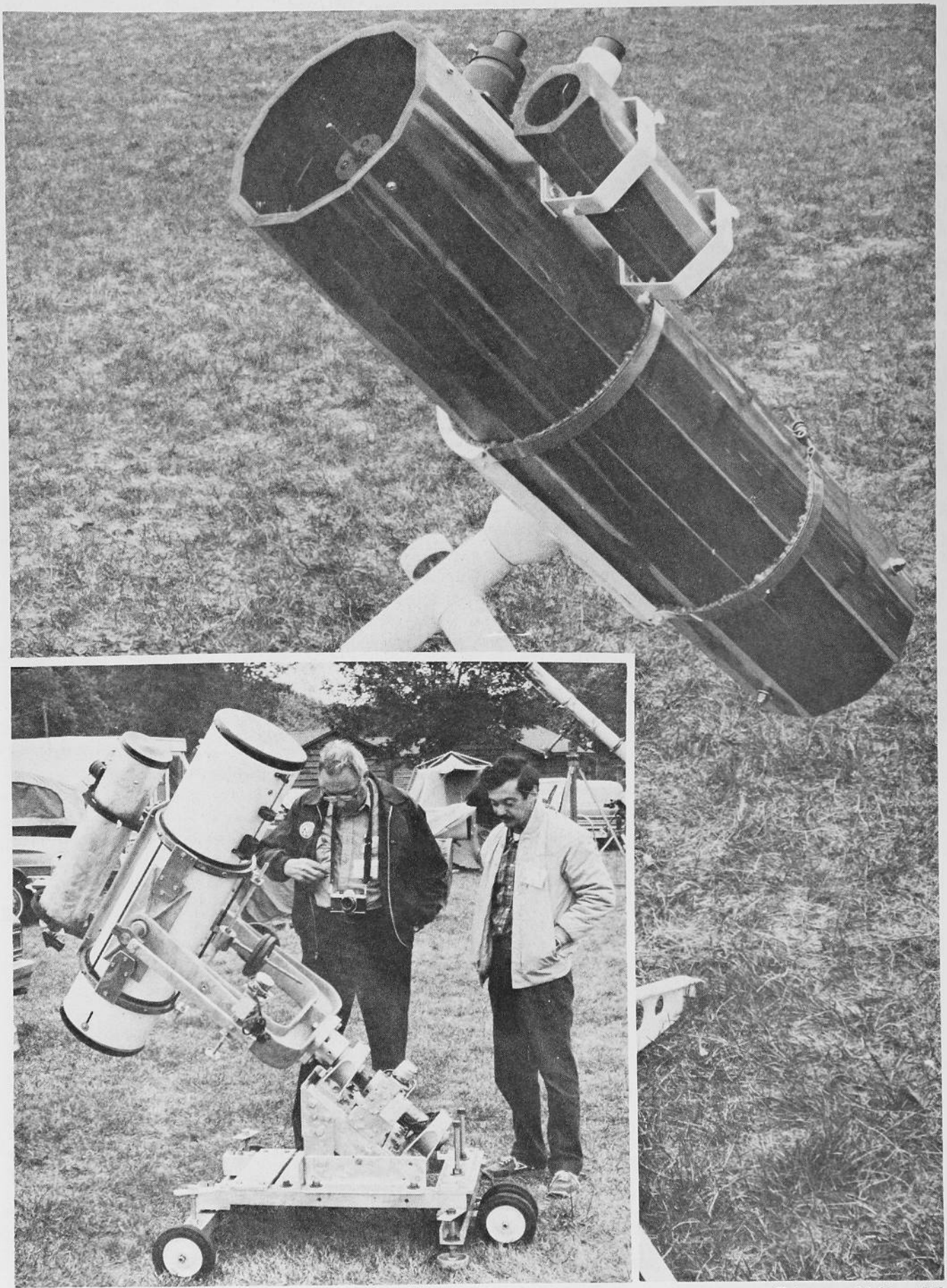
Above: Bob Karas describes his astrophotography rig. The unit consists of a C-11 mounted on a Byers 812 which he extensively reworked — externally, it is now sky blue. Internally, he re-machined many of the castings and refinished many of the surfaces. Karas described his careful investigation of the gear errors on this and two other mountings. He found tooth-to-tooth errors of approximately 30 arc-seconds using Albireo as a test subject. He found far smaller errors on a 10″ Byers gear he had purchased several years earlier.

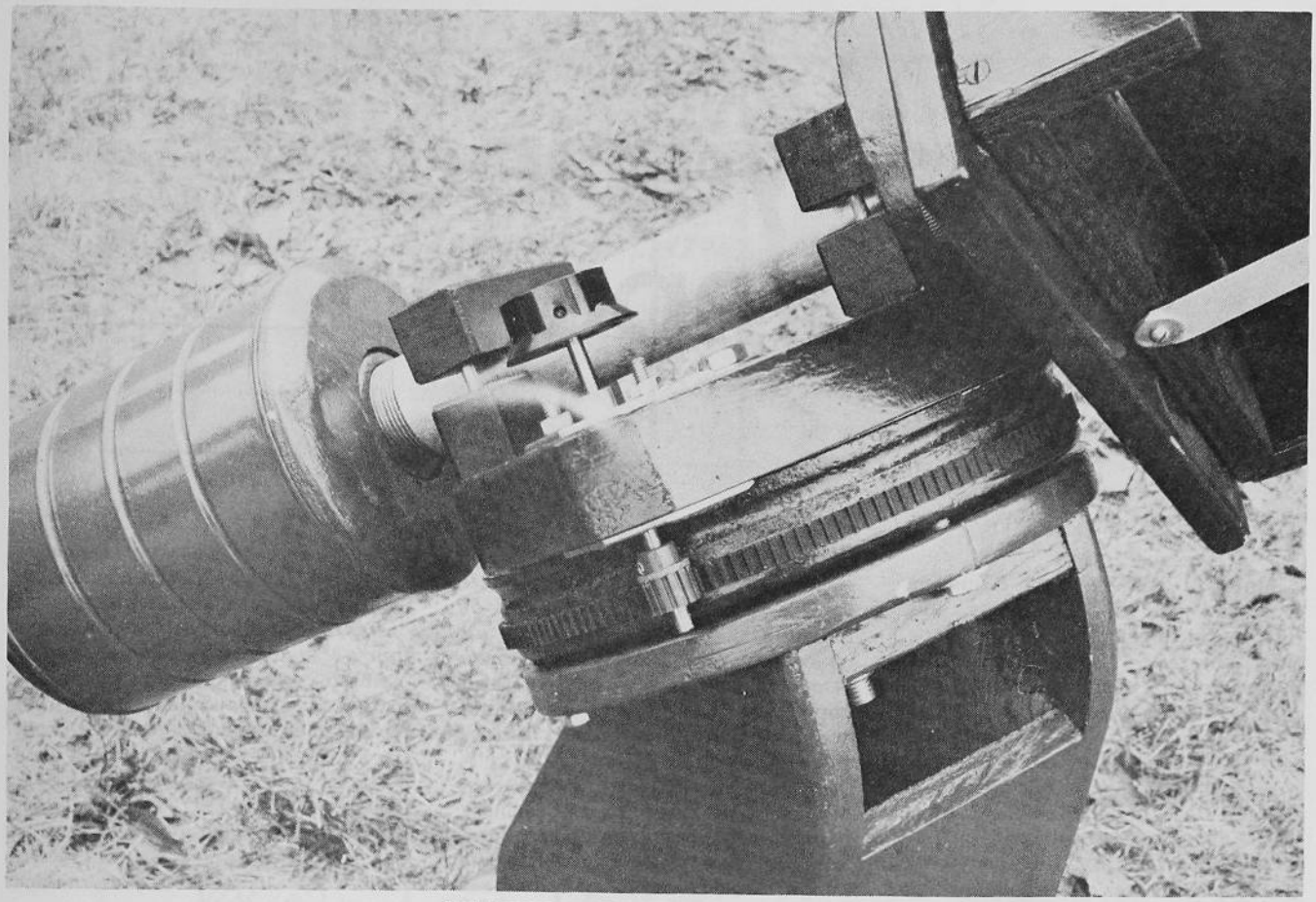


Above: About one-third of the telescope field at the '82 'Fest early Saturday morning. Heavy clouds and light mist probably kept attendance down this year, but the meeting was well managed and pleasant. Bunkhouses in background (among deciduous Illinois trees) provided sleeping-bag accommodations for those without tents or campers.



Left: John Phelps' stubby 17.5″ drew a lot of comment, one of the few telescopes that stayed on display for any length of time. Why? For safety's sake. When it's on display, he closes the tube with a sheet of ⅛″ plastic. This proved useful in deterring the AstroFest mist. The telescope features a knock-down rocker, eyepiece rack, and two-part tube. Rear view of tube (right) shows the detachable mirror cell. Note steps which allow it to tuck into the rocker efficiently, and aluminum strap carrying handle. Round object is a lead weight.





Left: Jack Brisbin built a lusterous cedar wood tube for his 8″ f/4.5 Newtonian and its little reflecting finder. Brisbin described his tube-building methods and passed around bits of partially finish tube at his paper. Left, inset: Marco Ricci's portable 10″ f/4.5 astrophotography rig has an Astroworks fork casting, but everything else he built himself. Ricci, right, stabilizes the setup with four support pads at front and back.

Above: Another wooden telescope from Richard Berry! This close-up shows the flat-plate mounting described in "Rethinking the German Equatorial" (available in *RTMC-82 Proceedings*, Orange County Astronomers). This mount uses a "rubber gear" made from a timing belt for a 25:1 combination slew/slow motion control in RA. The polar bearing is a 10″ disk of PTFE between two 10″ diameter by 1½″ circular wood bearing plates. Below: John Nehls stands beside his modified DS-16. Unfortunately, poor weather prevented star testing this low-cost commercial instrument. Nehls' modifications were primarily of the mounting.

Six Eyepieces Compared

Introduction

Although the eyepiece forms an important part of a telescope, this crucial optical device often seems to be the amateur's stepchild. This proposition can easily be illustrated by means of some examples:

- In perusing the many volumes of *Sky and Telescope*, we found hardly any articles about eyepieces. Mirror and lens objective systems, however, have received a great deal of attention.
- For many telescope manufacturers, the eyepiece seems to be the balancing item in their cost accounting. Sad to say, inferior eyepieces are not the exception, but the rule. And still sadder, the users of these telescopes are often not aware of this shortcoming and generally do not take the trouble to improve this situation.
- In the literature, there is no attention at all to the comparison and testing of different makes of eyepieces.

These and other reasons brought us to analyze this vital part of the telescope *comprehensively*. In this article, we will first discuss general aspects of eyepieces. Next we will consider optical ray-tracing of a number of representative eyepieces which are important for the amateur. The results of our ray-tracing give us an overall impression of the image quality and eventual specific characteristics of every single eyepiece.

In studying eyepieces, however, a problem arises: every type of eyepiece has numerous variants or modifications. To obtain complete insight into the image characteristics of all these variants would require a very comprehensive study of all the variant designs in the literature — which is, of course, too large a task for an amateur to undertake.

Fortunately a selection of designs with favorable characteristics has already been made from the multitude of types. The selection was made by someone who is an expert in this field — the director of the development department of the Carl Zeiss factory: H. Kohler (see reference 1).

Five of the examples we studied were suggested by him — each an example which can be considered representative of a particular type of (quality) eyepiece that is offered on the market at present. Naturally, the exact design we studied may not correspond exactly with that particular type being sold. Apart from the five Carl Zeiss makes, which were designed before 1960, we examined a very recent design (1977, ref. 2) in order to investigate how far this eyepiece, that has been designed by computer optimization, differs in its performance from the other types.

A Few Eyepiece Facts

An eyepiece is, in fact, a magnifying glass which makes it possible to examine the image formed by the objective in the focal plane closer than is possible with the unaided eye. With this simple statement, however, far from everything has been said. For the sake of completeness and a thorough understanding, it is desirable to go into some of the aspects which play a role in eyepiece performance.

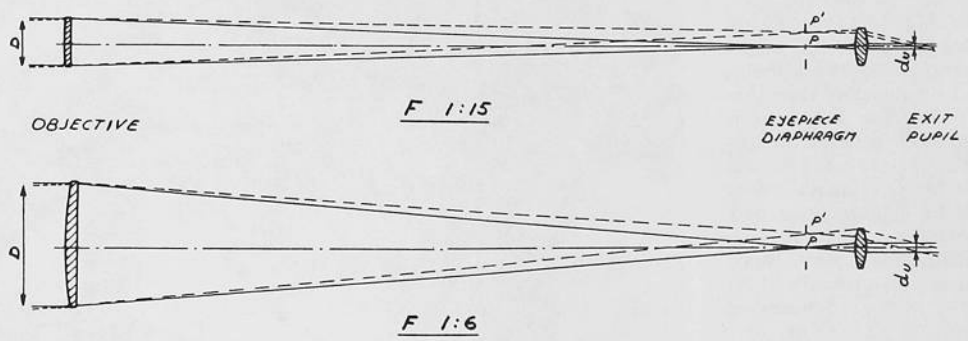


Fig. 1 *Two telescopes with different focal ratios.*

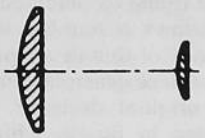
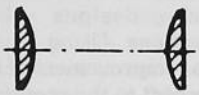
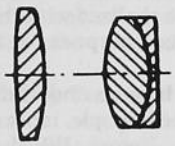
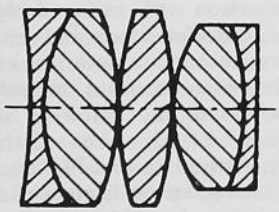
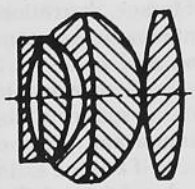
SCALE: FOCAL LENGTH	NAME	APPARENT FIELD DEGREES	YEAR PROTOTYPE	REMARKS
	HUYGENS	40	1703	THE FIRST COMPOUND TWO LENS EYEPIECE. WITH THIS TYPE THE ANNOYING LATERAL COLOUR COULD BE ELIMINATED.
	RAMSDEN	40	1783	—
	KELLNER	50	1849	ACHROMATIZED RAMSDEN
	PLÖSSL	60	1860	—
	ABBE	50	1880	ALSO CALLED ORTHOSCOPIC EYEPIECE BECAUSE OF ITS LOW DEGREE OF DISTORTION.
	ERFLE	70	1917	THE FIRST GENUINE WIDE ANGLE EYEPIECE DEVELOPED FOR MILITARY APPLICATIONS.
	ASTRO-PLAN-OKULAR	50	1955	DEVELOPED BY ZEISS FOR ASTRONOMICAL APPLICATIONS
	FLEISCH-MAN	50	1977	EYEPIECE DEVELOPED BY MEANS OF COMPUTER OPTIMIZATION.

Fig. 2 *Important milestones in the development of telescope eyepieces.*

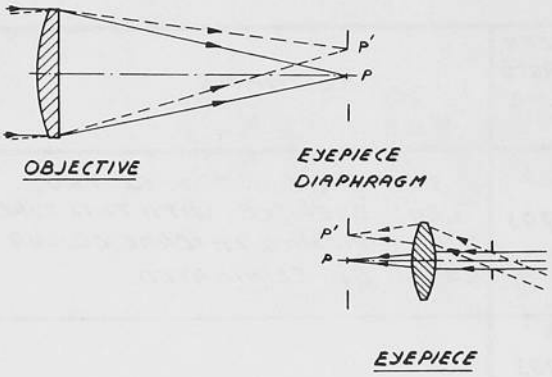


Fig. 3 Ray-Tracing an Objective and an Eyepiece.

In ray-tracing an eyepiece, the beams are reversed with respect to reality, whereby image aberrations, which occur at the eyepiece diaphragm, will be checked. The exit pupil becomes a fictitious entrance pupil!

In fig. 1, we compare two telescopes with different focal ratios (f/6 and f/15). The focal lengths of the objectives and the eyepieces are the same in both cases. For the sake of simplicity, both the objective and the eyepiece were drawn as single elements. Let us follow the extreme rays of a pencil of light (originated by a star), which enters the objective parallel to the optical axis.

The two rays will intersect in the plane, at point P, and after passing through the eyepiece, will emerge parallel again. The unaccommodated eye lens, which is located behind the eyepiece, concentrates this parallel pencil to a point on the retina.

In front of the eyepiece, the eyepiece diaphragm is located. The point P1, located at the edge of this diaphragm, is the most oblique beam of light which can still be observed by the eye. This oblique cone (indicated by dotted lines), after passing the eyepiece, will exit as a parallel pencil as well. The intersecting plane of both pencils forms the exit pupil. Note that the exit pupil is the image of the entrance pupil formed by the eyepiece.

The diameter of the beams coming out of the eyepiece is:

$$d_u = \frac{\text{diameter entrance pupil}}{\text{magnification}} = D/M$$

The angle alpha between the parallel and the oblique exit pupils corresponds with the half of the apparent field of this particular eyepiece. This is the angle that the eye must be rotated along between the center and the edge of the image field. The size of the apparent field can be calculated (with an accuracy of one or two degrees) from the ratio:

$$\varepsilon = \frac{\text{diameter eyepiece diaphragm}}{\text{eyepiece focal length}}$$

Epsilon can also be calculated from the formula:

$$\text{alpha} = 1.9 \times \arcsin(\text{epsilon}/2)$$

An average amount of distortion of the eyepiece has already been included in this formula and it is valid for an apparent field of a maximum of 80°.

The following table of epsilon may also prove useful:

epsilon	apparent field
0.52	30°
0.70	40°
0.88	50°
1.06	60°
1.2	70°

Eyepieces with an apparent field (i.e., twice alpha) of at least 60° are called wide-field eyepieces.

Few people know that the position of the exit pupil for a particular eyepiece depends rather strongly on the focal length of the objective. When the objective has a short focal length, as, for instance, in the case of binoculars, the position of the exit pupil is farther away from the last lens surface of the eyepiece than when the same eyepiece is used in combination with an objective of long focal length. This movement of the exit pupil also causes a change of the rays through the eyepiece. The combination of a binocular eyepiece with a telescope objective with long focal length will not generally be optimal.

Figure 1 shows that the diameter of the exit pupil has its largest size with the highest focal ratio of the objectives with a large focal ratio. A large exit pupil can cause unaccceptable image aberrations in certain eyepieces. We will investigate how far the image quality of all the examined eyepieces will be influenced by the focal ratio of the objective.

History of Development

The telescope eyepiece has a long history of development. Between the very first compound two-lens design (the Huygens) until the modern multi-lensed eyepiece, about 250 years have passed. Without trying to reach completeness, fig. 2 shows a number of important milestones of this development.

An eyepiece generally bears the name of the original designer. The types, mentioned in fig. 2, which were all drawn at the same scale, are not the original designs but recent modifications. Using modern kinds of glass, an improvement of image quality with respect to the prototypes could be attained and also a larger apparent field could be realized with the same or even improved sharpness at the edge of the field.

The Huygens and Ramsden eyepieces have, for example, more or less gone out of use. Before WWII, these simple eyepieces were appreciated because of their low internal reflections. After the war, however, coating techniques were improved to such an extent that this aspect is now far less important when choosing an eyepiece, and multi-lens eyepieces with improved optical characteristics can now be used to advantage. The eyepiece types shown in fig. 2 (with the exception of the last one) were all designed before 1960, when optimizing computer designing programs were not yet available. The Fleischman eyepiece is a result of computer-aided design. This has led, in comparison with earlier designs, to a strongly deviated form and considerably improved optical performance. In our further considerations, we will restrict ourselves to the following six types: Kellner, Plossl, Abbe Orthoscopic, Erfle, Astroplan, and Fleischman.

A characteristic difference between an eyepiece and an objective concerns the size of the image angle. In contrast with an objective, which typically has an image angle less than 2°, the image angle of an eyepiece sometimes amounts to 70°. Consequently, much attention must be paid to the correction of off-axis aberrations. Ref. 3 gives a survey of image aberrations which can be present in optical systems. Spherical aberration and color on the axis are normally well-corrected in eyepieces. Nevertheless, spherical aberration can play an important role in certain types of eyepieces if a large exit pupil (i.e., a large focal ratio) is used.

Another aberration which is very annoying is lateral color. This means that the magnification of the image depends on the color of the light. This manifests itself by more or less strongly colored fringes around objects off the

optical axis. Astigmatism and coma also cause unsharpness in the outer parts of the field. Sometimes eyepieces also suffer from curvature of field. This means that the highest image sharpness is not situated on a flat but on a curved plane. This can be annoying because this phenomenon leads to unsharpness in the outer parts of the field if the focal plane of the objective is flat.

Finally, distortion can be considerable, especially in wide field eyepieces. In general, this aberration is less disturbing in astronomical observation than in terrestrial observation, so that no attention will be paid to this phenomenon in this article. We shall investigate the combined effects of the mentioned image aberrations, with the exception of distortion.

Optical Ray Tracing

Ref. 3 gives a comprehensive description of the method of ray tracing of mirror and lens objectives through self-developed computer programs, and of how image quality can be checked by means of spot-diagrams. In principle, this can also be applied to eyepieces — but there are some differences.

The principal schemes for ray tracing are shown in fig. 3. In ray tracing an eyepiece, we assume that the light is reversed with respect to reality, i.e., parallel beams of light travel from the eye to the eyepiece. This method of calculation is easier than following the real course of the light rays which would require investigating the image formed on the retina.

This fictitious reversal of the rays in an eyepiece leads to the same conclusions with respect to the image aberrations as in the case of the real passing of the rays through the eye. The entrance pupil of a visual astronomical objective is normally formed by the first encountered mirror or lens surface. In the case of an eyepiece, however, the "entrance" pupil is situated in front of the first lens, and so is outside the system. The sizes of the entering pencils are limited by a fictitious diaphragm which is placed "in front" of the first lens.

Table 1 lists the optical data of the six eyepieces we traced. For these particular eyepieces, we calculated spot diagrams for the following conditions:

- image angles from the optical axis: 0°; 10°; 20°; 25° and 30°
- for the colors:
  blue (486.13 nm)
  yellow (587.56 nm)
  red (656.27 nm)
- for focal ratios of the objective: f/6 and f/15.

The results of our calculations are given in fig. 5, in the form of spot diagrams. In order to obtain an impression of the color aberration outside the optical axis, you must compare the relative position of the intersecting points of the principal rays with the focal plane for blue and red with respect to yellow. We have omitted the spot diagrams for these colors because of their similarity and almost equal size with respect to the yellow spot diagrams.

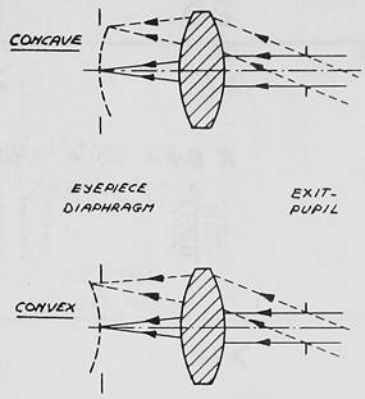


Fig. 4 *Concave and convex field curavature of an eyepiece.*

Fig. 5 allows a comparison between the size of the spot diagrams and criteria for good image quality:

- at the center of the field, the spread of spots for the combined spot diagram for all colors should not be more than one minute of arc (corresponding with the maximum resolution power of the eye for brightly illuminated objects); and
- at the edge of the field, a spread of five minutes of arc is allowable.

Spot diagrams larger than 12 minutes of arc are not shown.

We assumed that all eyepieces have a flat focal field. This supposition is, as a good approximation, correct for all eyepieces under consideration, with the exception of the Astroplan. In fig. 6, we have computed results for this particular eyepiece with a curved field as well. It is clearly shown here that the image sharpness on the curved field is considerably better than for the flat field.

It is legitimate to ask which of the two rows of the spot diagrams in fig. 6 are relevant for judging the image sharpness attainable under real observing conditions. As shown in fig. 4, curvature of field can be concave or convex. The Astroplan has a relatively strong concave (i.e., inward curving) field. Within certain limits, accommodation of the eye can compensate curvature of field. In this particular case, the observer should then focus on the edge of the field with an unaccommodated eye and accommodate as much as necessary when viewing the center. It is an empirical fact that accommodation over a certain level (approximately three diopters for young observers and one diopter for older observers) after some time will become fatiguing. Therefore an observer normally will observe with an unaccommodated eye and focus on the center of the field, whereby the edge of the field will appear unsharp in this particular case.

In using an Astroplan for observing, a simultaneous sharp picture for center and edge requires an accommodation of one dioptric at an eyepiece focal length of 35mm, an amount of accommodation which increases with decreasing focal length. From the foregoing, therefore, we may conclude that the Astroplan spot diagrams, as given for the flat focal plane in fig. 5, are a better criterion for judging the image sharpness than those given for the curved focal plane in fig. 6. This conclusion is most warranted for eyepieces of short focal length.

Conclusions

In judging the results of the calculations, a clear distinction should be made between, on the one side, the five first mentioned more or less "classical" designs (Kellner-Astroplan) and on the other hand, the Fleischman eyepiece which is a representative of the newest generation of eyepieces.

With respect to the first mentioned group of "classical" eyepieces, we have drawn the following conclusions:

- The optical performance depends strongly on the focal ratio of the objective. None of the eyepieces are sufficiently corrected to give excellent performance over its entire field when combined with an objective having a focal ratio of f/6.
- Even if used with an f/15 objective, none of the eyepieces' images will be critically sharp more than 10° off-axis; and
- The sharpness at the edge must also be considered insufficient even at f/15.
- The wide-field Plossls and Erfles possess a rather strong lateral color aberration. Apparently the increase of the width of the field has led to a worsening of the color correction. In the literature, some Plossl eyepieces are reported to be very well-corrected with respect to color aberration, though these designs have apparent fields of no more than 50°.
- With respect to the Astroplan, the sharpness obtained on the curved field roughly meets the requirements of the above mentioned maximum spread of spots. Sharp observation of objects outside the optical axis, however, will require a refocusing by moving this particular eyepiece forward. In that

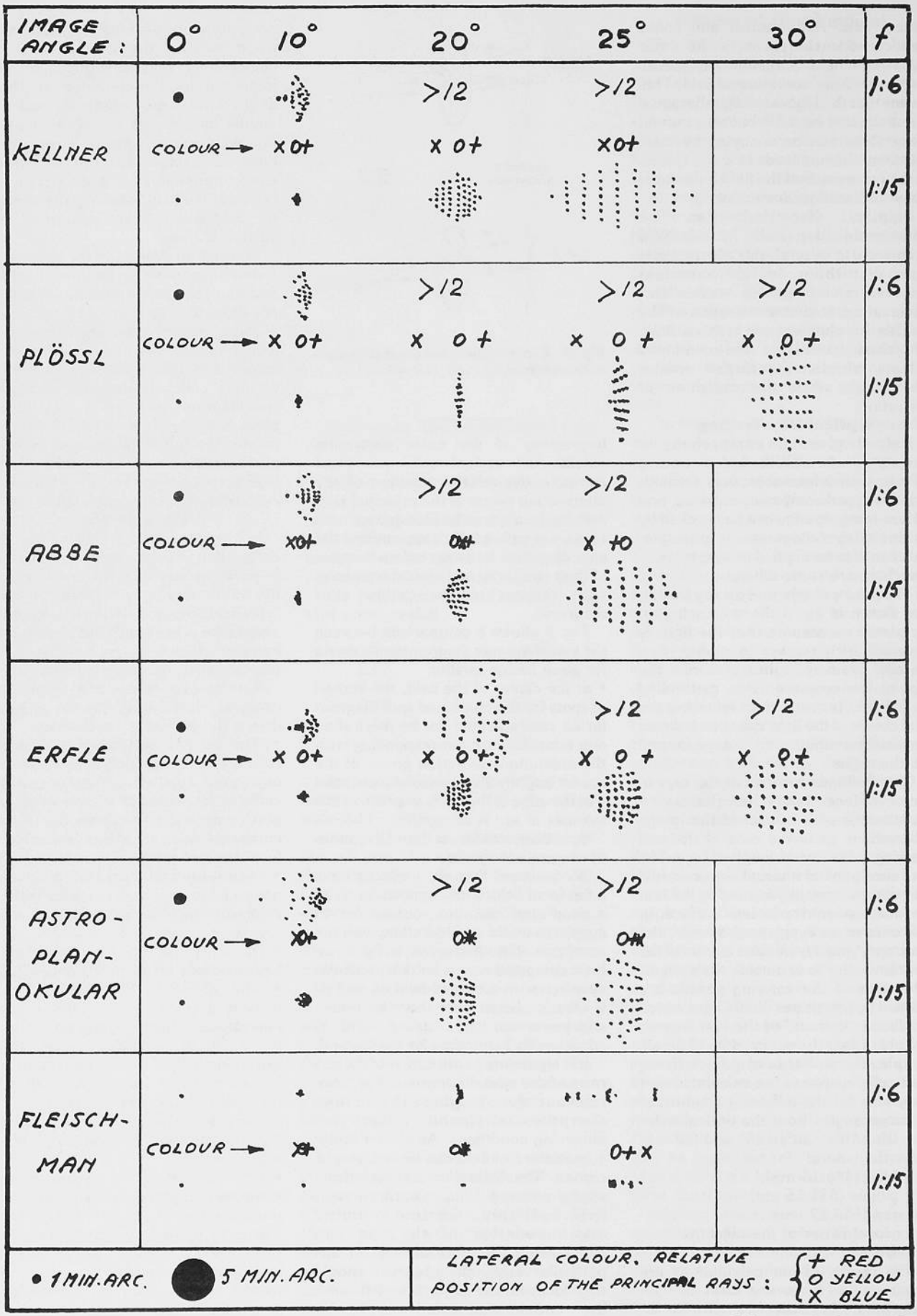


IMAGE ANGLE :
0°
10°
20°
25°
30°
f
KELLNER
PLÖSSL
ABBE
ERFLE
ASTRO-PLAN-OKULAR
FLEISCH-MAN
COLOUR →
>/2
1:6
1:15
• 1 MIN. ARC.
5 MIN. ARC.
LATERAL COLOUR. RELATIVE POSITION OF THE PRINCIPAL RAYS :
+ RED
O YELLOW
X BLUE

Fig. 5

case, of course, the center of the field will become unsharp, as far as the accommodation of the eye is not able to compensate.

The Fleischman eyepiece represents a completely new generation of eyepieces, with strongly enhanced image performance, designed by means of computer-optimization. Modern and expensive glasses are used here. This eyepiece is much more satisfying at a high focal ratio (f/6) than the other types shown. At a focal ratio of f/15 this eyepiece can be considered almost perfect, giving good image sharpness coupled with small color aberration and a flat field.

Final remarks

In this article, a comparison was made of the optical performance of a number of telescope eyepieces. This comparison relates only to the visual use of these eyepieces, with parallel exit pupils. In the case that these are used as projection eyepieces for lunar and planetary photography, the exit pupils will no longer be parallel, causing additional image aberrations. The results given in fig. 5 then lose their validity.

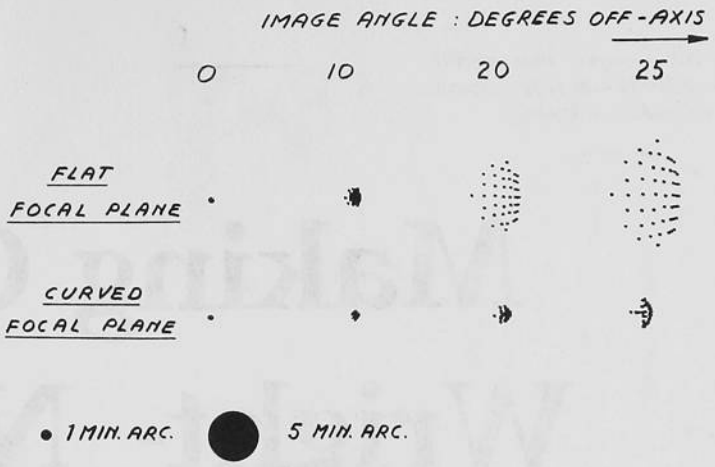


Fig. 6 *Spotdiagrams for the astroplanokular — for the flat and the curved focal plane. (Focal ratio f/15.)*

Table 1. Optical Characteristics of the Six Eyepieces

Name of the Eyepiece		Kellner	Plossl	Abbe	Erfle	Astro-Plano-Kular	Fleischman
Distance field stop	f/6	60.51	55.18	56.16	39.4	76.21	18.15
to first lens	f/15	61.09	55.56	56.63	39.75	76.825	18.15
R1 (Radius of curvature)		376.92	361.62	184.07	-465.1	-205.74	∞
T1 (Axial thickness)		21.86	8.49	31.31	9.8	6.26	5.75
M1 (Medium)		SK 16	SF 10	Ba F5	SF 12	SF 10	SF 57
R2		- 163.43	96.6	- 77.53	136.13	281.77	91.71
T2		45.76	50.95	6.25	55.01	18.69	8.95
M2		Air	PSK 3	SF 14	PSK 3	SK 7	Air
R3		86.82	- 144.85	77.53	- 179.54	- 133.18	623.74
T3		34.42	7.69	34.31	0.7	0.6	21.59
M3		SK 14	Air	SK 7	Air	Air	La K 17
R4		- 79.47	100.89	- 156.06	246.05	236.05	- 83.34
T4		5.72	40.26	0.6	39.31	18.69	11.23
M4		SF 10	Ba F 5	Air	FK 5	SK 7	Air
R5		- 1190	- 127.87	101.04	- 246.05	- 471.11	- 52.46
T5			16.98	21.91	0.7	0.6	6.71
M5			SF 12	SF 10	Air	Air	SF 57
R6			- 744.22	∞	107.02	82.99	- 294.99
T6					52.31	21.77	36.61
M6					PSK 3	SK 2	La KN 9
R7					- 176.04	- 262.19	- 71.44
T7					9.8	6.26	0.67
M7					SF 12	SF 10	Air
R8					- 3020.62	305.13	204.85
T8							27.8
M8							La KN 9
R9							- 204.85
Distance last lens to exit pupil		58.6	60.7	81.4	61.5	82	113.2

Based On A Focal Length of 100 MM

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References

1. *Die Fernrohre und Entfernungsmesser.* Konig/Kohler, Springer-Verlag, page 161
2. US Patent 4, 054,370; 18 October 1977
3. "Nine Telescope Systems, Compared by Means of Optical Ray Tracing", *Telescope Making 14*, H.G.J. Rutten and M.A.M. v. Venrooij
4. *Lens Design Fundamentals*, Rudolf Kingslake, Academic Press, 1978
5. *Modern Optical Engineering*, W.J. Smith, McGraw-Hill, 1966
6. *Fundamentals of Optics*, F.A. Jenkins and H.W. White, McGraw-Hill, 1957
7. *Optics*, E. Hecht, A. Zajac, Addison Wesley, 1974
8. *Applied Optics and Optical Engineering, Part III*, R. Kingslake, Academic Press, 1965
9. *Applied Optics and Optical Design, Part I and II*, A.E. Conrady, Dover Publications, 1960
10. "Teleskope," from *Handbuch der Physik*, K. Bahner, Bd XX1X, pag. 227 e.v.
11. "Optik fur Astroamateure," E. Wiedemann, *Orion* 29 j.g. (1971), no. 126 pag. 153 e.v.
12. *Handbuch fur Sternfreunde*, G.D. Roth, Springer Verlag Berlin, 1960
13. "Amateur Telescope Making," 1, 11 en 111, A. Ingalls, *Scientific American*, 1971

Making Correctors
Wright- Newtonian

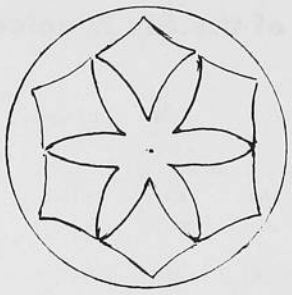
The Wright telescope is similar to a Newtonian telescope, but instead of a single parabolic mirror, it has a Schmidt corrector plate and spherical mirror. The design, which was described by Franklin Wright in *ATM 2*, places the corrector near the focus rather than the radius of curvature as in a Schmidt camera. The primary purpose for building such a telescope is to eliminate coma, the major aberration in short focus instruments. By mounting the diagonal on the plate, you also eliminate spider diffraction and, of course, the sealed tube reduces air currents.

A focal ratio of f/4 is as fast as you want to go with this type of telescope — anything faster and you'll end up with large aberrations from the eyepiece, exit pupil and diagonal size problems, and increasing difficulty with collimation.

To start with you'll need a corrector blank — either a plate glass disk or a molded blank. Aperture for these telescopes is mirror diameter, but to make figuring the edge zone and mounting it easier, the corrector should be larger in diameter than the aperture. Diameter thickness ratio should be about 20 or 25 to 1, since a thinner blank is likely to flex with the diagonal mounted on it and cause astigmatism, particularly with the scope pointed horizontally.

To mount the diagonal, you need a $\frac{3}{8}$" or $\frac{1}{2}$" hole cut through the center of the blank. I used a piece of slotted copper tubing in a drill press at low speed with #120 grit to cut this hole. You can mount the diagonal on the plate using a suitable cement, but this makes it adjustable only by moving the plate which should remain parallel to the mirror surface.

If you use plate glass, check for wedge around the edge of the blank with a micrometer. It should be within 0.0005" for a small blank, and within 0.001" for a larger blank. If you use a molded blank, you'll need to start grinding with #80 or #120 grit. Use your mirror blank and tool as tools for the plate. Label them 1, 2 and 3 — then grind in sequence: 1 on 2, 2 on 1, 1 on 3, 3 on 1, 3 on 2, 2 on 3 and repeat on the other side of the plate. Keep your strokes shorter with the plate on top and longer with the tool on the bottom. You can start correcting for wedge during the #220 size grit. Mark the high spot on the disk and sprinkle abrasive on this side, tapering off to nothing on the other side. Rotate your tool after each wet but not during the wet.



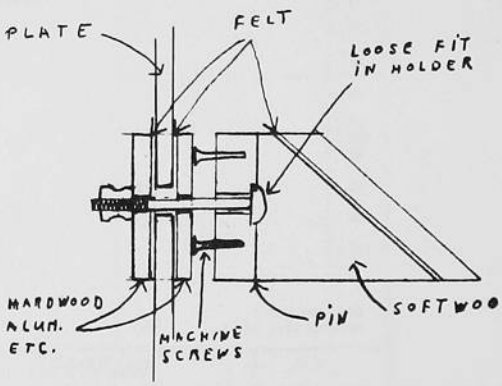
After fine grinding the plate, complete your spherical mirror and have it aluminized. The mirror will be used to test the plate.

You will need a "roseleaf" lap made of medium pitch and poured fairly thick ($\frac{1}{8}$" to $\frac{1}{4}$") on your tool bank. Probably the easiest way to make this lap is to cut the leaf shapes out of a disk of balsa or corrugated cardboard, paste this to your tool, pour pitch around each leaf mold, then carefully cut away the wood or cardboard. Warm press this lap on your plate until each leaf is the same height and then facet the lap with a sharp razor.

Use cerium oxide with the tool on top. Polish each surface using very short strokes. Polishing time should be about 6 or 7 hours for each side, but this will depend on the focal ratio and the size of your plate.

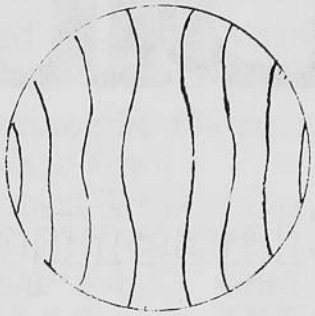
For testing, you will need two thin disks of wood which fit tightly into your eyepiece holder. One disk has a $\frac{1}{8}$" hole in the exact center and the other has two $\frac{1}{8}$" holes $\frac{1}{4}$" apart on opposite sides of center. Mount a Ronchi screen on this disk and shine a light through one hole so it passes through the optics and returns to the other hole. For a light source I use a nightlight wired to a cord and a 4-watt bulb covered with foil with a $\frac{1}{4}$" hole — a crude but effective light source.

You can modify a commercial diagonal holder or make your own. The type I use is adjustable only by removing it from the plate, but I prefer this to drilling more holes or a single, larger hole through the plate. To hold the plate, I use plywood or hardwood rings mounted with three or four $\frac{1}{4}$" machine



or elescopes

When you begin working the corrector, your bands will probably look something like this.

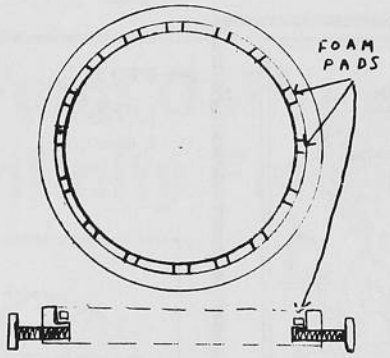


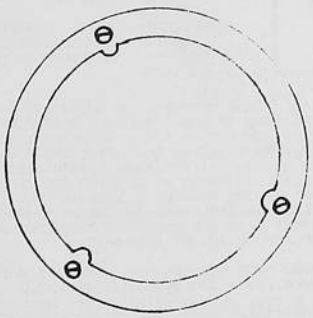
screws through adjustment slots in the tube. The plate sits on a ring of small foam pads and is lightly held down with another disk with pads.

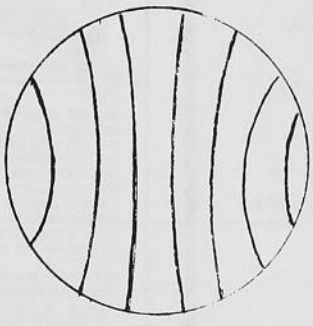
Collimate the tube assembly with the plate holder equidistant from the edge of the tube. Use a tiny red dot in the center of your mirror and align this dot with the hole in the center of the wood disk in your eyepiece holder. Put in the other disk with the Ronchi screen, shine your test light through one hole, and while looking through the other, adjust the correcting plate holder until you pick up reflected bands from it. Center these bands — this insures that your plate is mounted parallel to your mirror surface. Recollimate and repeat the process.

Beg, borrow, or make an optical flat. You can get by with a pretty poor one, one made, for example, from the flat surface of the tool used to grind the plate. Test it using the spherical mirror (as described in *ATM Book 1*). Although the focal length of the mirror should be somewhat longer for best results, you only need to make your flat accurate to about one wave. You will do your final testing on a star.

I set up my optical flat on a piece of plywood with three adjustment screws which sit astride the plate holder. Three tabs on this disk hold the optical flat. With an uncoated flat you'll be dealing with 3 or 4 reflective surfaces, 2 from the plate and 1 or 2 from the flat. Place a paper tab between the flat and plate so you'll know which of the sets of Ronchi bands is the right set — those move behind the tab when you move the flat holder.







Inside the focus of an uncorrected system.

When you begin testing, the plate will be undercorrected — something you can check by testing the system without the corrector in place. Your plate will probably show something like the illustration: convex bands in the center (i.e., overcorrected, or curved too much) and concave bands at the 70% and edge zones (i.e., undercorrrected, or not curved enough). If this is the case, use a flat lap ⅓ the diameter of the plate to flatten out the center and a small 1″ or 1½″ lap applied with a circular motion around the entire plate to deepen the edge and 70% zones. Turn the plate frequently and test after about 10 minutes.

It is easy to scratch the plate at this stage, so be careful. When your bands are almost straight, remount the Ronchi screen in the other wood disk and move outdoors. Set up your tube on Polaris or another bright star near the pole, let everything come to temperature, then complete testing and polishing and testing again on the star. When the bands are perfectly straight, you're done.

I haven't made a Schmidt camera or Cassegrain yet, but I see no reason why this test shouldn't be applicable to these types of optics. Note that for the camera, you'd need a diagonal mirror to direct the rays off to the side through the Ronchi screen. Since Schmidt cameras are faster than Wright Newtonians, they require deeper curves in the plate so you might have to fine-grind part of your curves into the plate before polishing.

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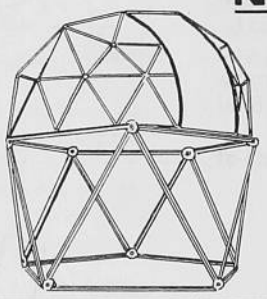

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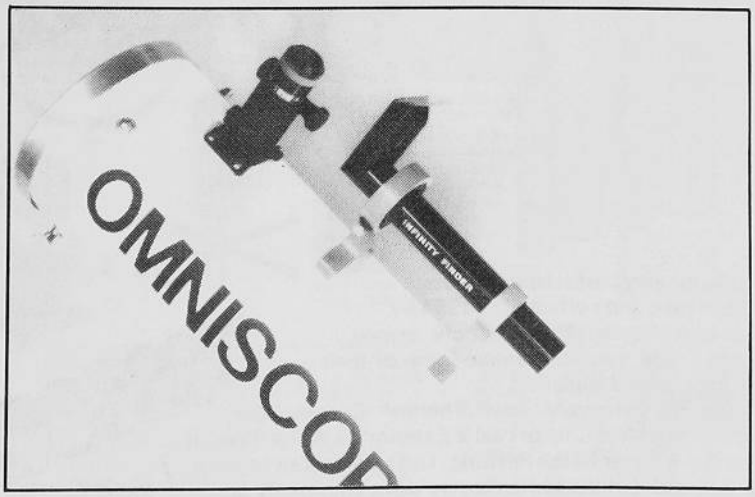

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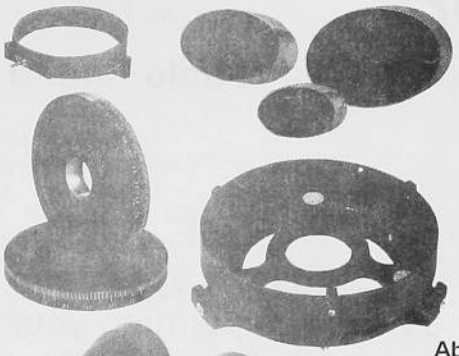

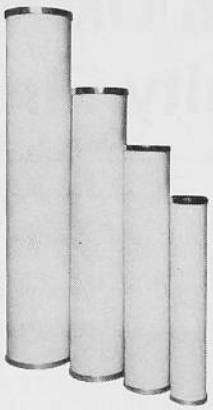

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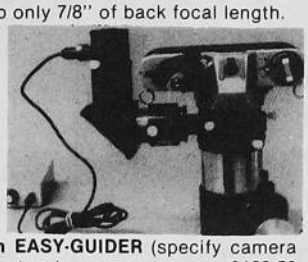

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4. Filters to stop light pollution
5. SUPER-FINDER makes life easy

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10" Mead 2120	$1298	$1689	$1898
Celestron-11	$1395	$1893	$2583
Celestron-14	$3190	$4890	$5580

**Includes telescope, wedge, tripod. Special coatings: C-8, 2080 add $79; C-11, M-2120, add $140; C-14, add $215*

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†Patent Pending.

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For optimum astronomy, use **both** the **LUMICON DEEP-SKY FILTER** and **UHC FILTER.**

DEEP-SKY FILTER™

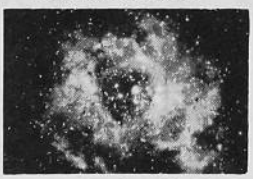

Photo by Dr. J. Marling 8"f/4.5, 60 min, hypered 2415

Rosette Nebula photo with a Deep-Sky Filter Visually, this is best seen with a UHC Filter.

The **LUMICON DEEP-SKY FILTER** improves your view of **all** deep-sky objects including galaxies and comets. It removes natural and man-made light pollution and yields 3-6X contrast gain form nebulae and 1-3X contrast gain for clusters and galaxies. It is ideal for **both** visual use and B&W or color photography. This gentle filter yields the most natural view of any LPR filter available today. 90nm visible bandpass, 442-532nm. H-Alpha 656nm transmission = 75-95%

	Standard	Premium*
0.965" LUMICON DEEP-SKY FILTER for C-90, C-5, refractors, etc	$49.95	$59.50
1¼" LUMICON DEEP-SKY FILTER threads into most 1¼" eyepieces	$59.50	$79.50
1¼" LUMICON UHC FILTER threads into most 1¼" eyepieces	$79.50	$99.50
Set of Both 1¼" **DEEP-SKY** and **UHC FILTERS** (Save 15%)	$119.95	$149.95
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48mm LUMICON DEEP-SKY FILTER (1.75" aperture), threads into most 2" eyepieces	$99.50	$119.50
48mm LUMICON UHC FILTER (1.75" aperture), threads into most 2" eyepieces	$99.50	$119.50
Set of Both **48mm DEEP-SKY** and **UHC FILTERS** (Save 15%)	$169.95	$199.95
2" LUMICON DEEP-SKY FILTER (1.5" aperture), threads into most 2" eyepieces. Also has male and female camera T-threads for prime focus photography	$99.50	$119.50
Telephoto lens adapter for 2" or 48mm filter. Select 46, 49, 52, 55, 58mm		$6.95
Universal adapter for 1¼" filters. Adapts the 1¼" filters to any 1¼" eyepiece		$14.95
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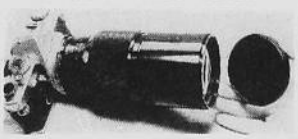
**Premium filters are selected best of the lot and typically have 5-10% high transmission. Not always available. Include individually measured transmission data.*

H-ALPHA PASS FILTER

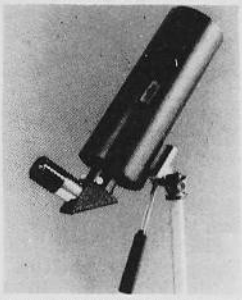


Yields spectacular contrast gains in B&W photography with telephoto lenses. Yields pinpoint star images. Superb with hypered 2415. For color, use the Minus Violet (MV) Filter.

Specify Lens Size	H-Alpha	(MV)
46, 48, 49mm	$29.95	$25.00
52, 55, 58, 62mm	$39.95	$29.95
67, 72, 77mm	$46.95	$39.95
82mm	$49.95	
Hypered 2415 film, 36 exp	$9.95	3/$26

PERFECT FOR LARGE TELESCOPES!

LUMICON SUPER-FINDER™



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IMPORTANT: Select 1¼" or 2" version and specify straight-through or right-angle viewing. Right angle version requires a star diagonal.

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Requires some soldering and drill and tap — one hole.

Model 640: A heavy-duty deluxe focuser with 3″ travel. Applicable to telescopes in the 6″ to 12½″ aperture range. Accepts 1¼″ O.D. eyepieces. **$87.95 ppd.**

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Model 680: As supplied with Meade Research Series reflecting telescopes (Models 880, 1060, and 1266). Includes thread-on eyepiece-holders for both 1¼″ and 2″ O.D. eyepieces. Travel length is 3″. An excellent focuser for 6″ to 16″. **$110.00 ppd.**

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Pursell's Platform

a southern alternative to the poncet

I had heard of the Poncet mount and had seen a few photographs of them, so I was delighted to read Robert Cox's article giving the basics of their construction in TM#8. His presentation showed me that I could make one with hand tools — and I was anxious to have a rotating platform under my 10″ Dobsonian. Furthermore, Cox's formulae for the critical dimensions:

$$R = (1440 \times rpm)/(2 \times \pi \times TPI)$$

where R is the radius of the equivalent worm gear, and:

$$L = (1440 \times rpm)/2 \times \pi \times TPI \times \sin(lat)$$

where L is the distance between the pivot and the drive, were invaluable. But lurking behind the math, these formulae imply that Poncet mounts are specific to a given latitude, not something you can easily change if you move north or south. However, I didn't realize that at the time.

So I set to work. For the surface parallel to the celestial equator, I used a portion of a sink cut-out working against Teflon pads. I chose a ½ RPM, 115 VAC 60-Hertz motor — Model CA from Hurst Mfg. Corp. of Princeton, IN — which I bought through a local radio/electric parts store, for the drive motor. Although the point of driving force (point "B" in the diagrams) is specific due to the formula, the motor position can vary somewhat. Indeed, it would be quite difficult to exactly align the motor shaft, threaded rod, and driving nut. The driving nut itself has a slight vertical and horizontal shift as it moves around its arc. Any misalignment causes stresses which can be harmful.

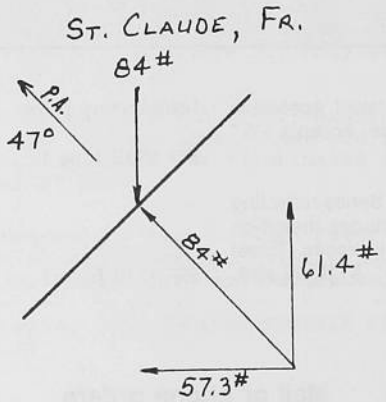
So, to eliminate these angular stresses, I made a simple universal joint out of ⅜″ pipe, 5/16″ square keyway stock, and 3/32″ cotter pins to go between the motor shaft and the threaded rod. That took care of one angle. I then made a simple gimbal for the driving point using the 5/16″x18 driving nut, a ½″ ring cut from a 1″ pipe, and some #8x32 machine screws. This was suspended in a 1¼″ pipe nipple in a 1¼″ floor flange attached to the underside of the top. The gimbal allows for the vertical and horizontal movement of the driving nut during rotation of the top.

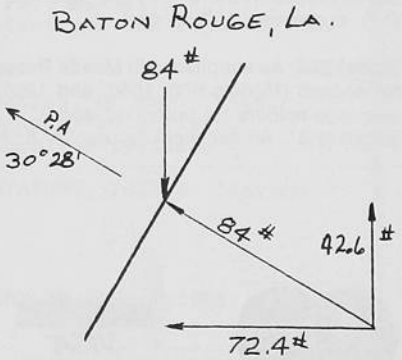
The pivot pin (point "A") is a ⅜″ bolt soldered into a hole bored into a small plate and attached to the base. Its top has a cap nut which sets into a ½″ chambered hole drilled into another small plate which is attached to a block dropped down from the underside of the top. The cap nut allows minor vertical adjustments.

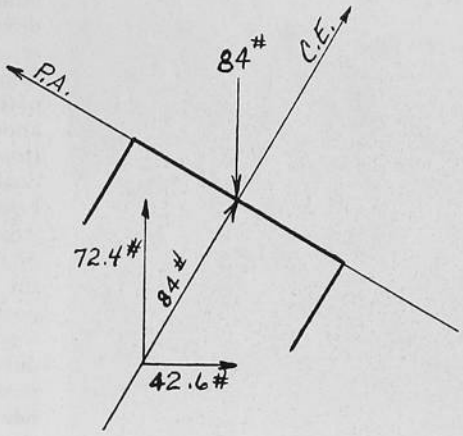
Note that the driving nut ("B") is a very specific distance from the pivot ("A") and the same distance above the base and below the top as the pivot's point of contact. This ensures that when the base is leveled at set-up, the top will also be level. Besides setting up on a north-south line, leveling the base assures polar alignment of the axis of rotation.

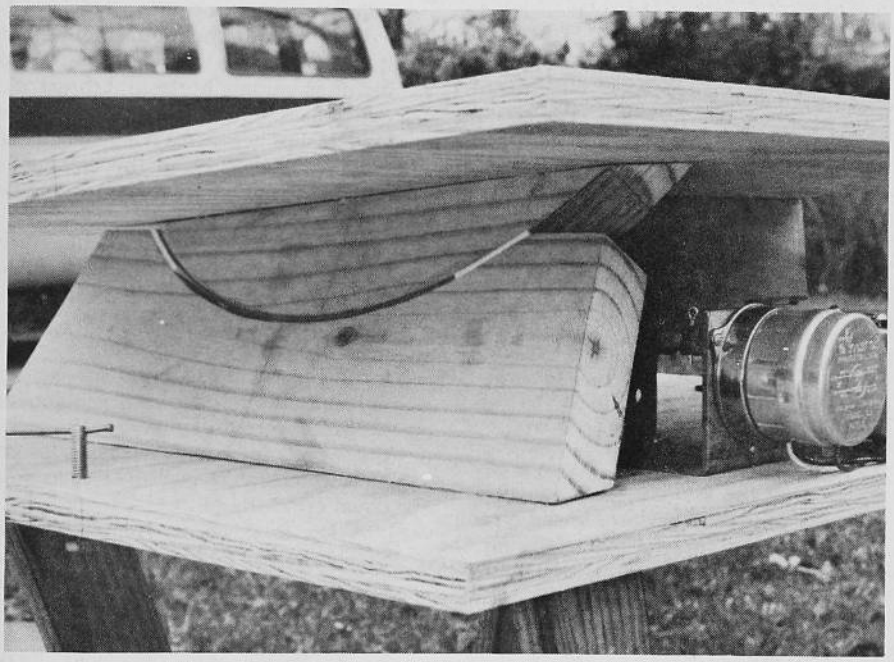
I was quite pleased the first time I used the mount, but my happiness had two qualifications: 1) Roughly one hour (15°) is the maximum time before the load on the platform becomes top-heavy and is likely to tip over at the start or finish of the run. I found 40 to 45 minutes (10° to 11° rotation) enough for a single set-up. 2) The top had a terrible tendency to jump off the pivot point. This was a serious problem — so serious, in fact, that it was intolerable.

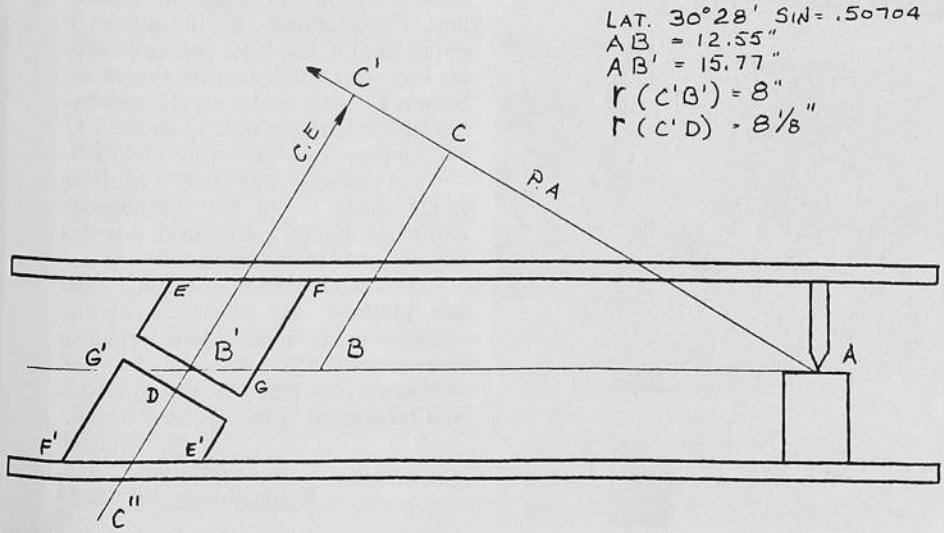
Just why the top wanted to keep jumping off the pivot pin bothered me since there was some 84 pounds of telescope supposedly holding it down! I attacked the problem graphically and mathematically and quickly found out why the mount worked so well for M. Poncet but not for me. The horizontal











vectors for M. Poncet at latitude 47° in St. Claude, France, and me down at 30° in Baton Rouge are quite different. The top of my mount tended to jump off the pin because 72 pounds, or 86% of the telescope weight, was converted to a horizontal force.

Thus the Poncet mount is probably not the best approach for any observer living south of latitude 45°, a line that runs from Portland, through Yellowstone, Minneapolis, Ottawa, and on to Bangor — most of the population of the forty-eight states, in fact. And the farther south you go, the worse the problem becomes! It occurred to me that maybe I could make latitude and trigonometry work *for* me instead of against. To do this, I simply rotated M. Poncet's contact surface 90° and came up with what is really nothing more than a portion of a horseshoe mount such as the one on Palomar Mountain. We now have a section of a rotating cylinder, most of which has been replaced by a horizontal platform cutting through it, with its axis pointing to Polaris. Now the horizontal force vector at latitude 30° represents only 42.6 pounds, or 50% of the weight of the scope. Note that the vertical and horizontal values have been reversed from the earlier figures for 30° — and it's also obvious that this design would be inappropriate north of 45°.

Although the formulae are the same, construction must be slightly different. For the top and bottom boards, I used ¾" plywood, 20" x 24" in both cases. The pivot point A, driving point B, and bottom center point of the convex arc B′ all lie on the same base line. If you begin by choosing the location of B′, that is to say you pick the length AB′, then you must calculate the radius of arc, R, by:

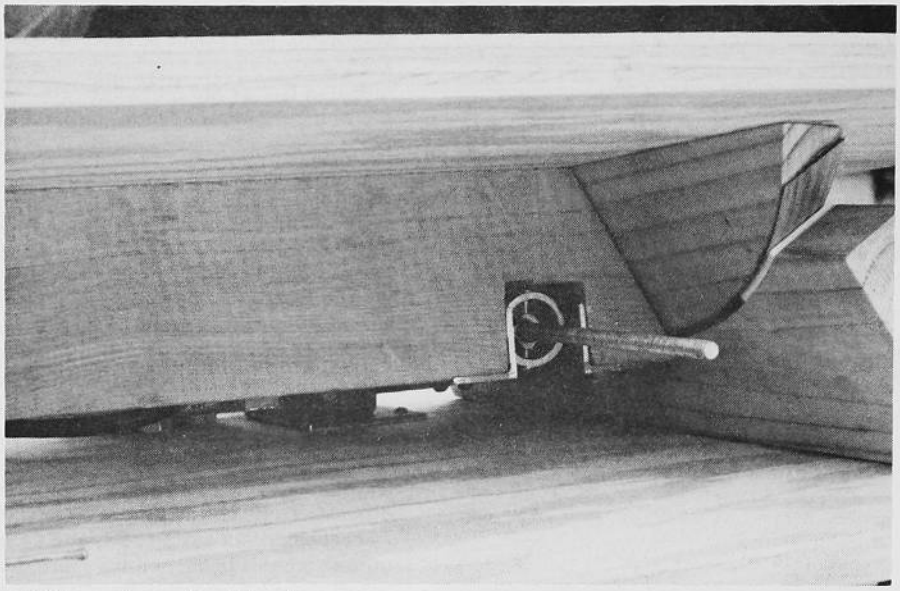
$$R = AB' \times \sin(\text{latitude}).$$

If you choose instead to designate the radius of the arc (as I did since I wanted to generate a curve to bend the Formica over), then you can find the length of line AB′, and thus the location of B′, from:

$$AB' = R/\sin(\text{latitude}),$$

where R is the radius you chose.

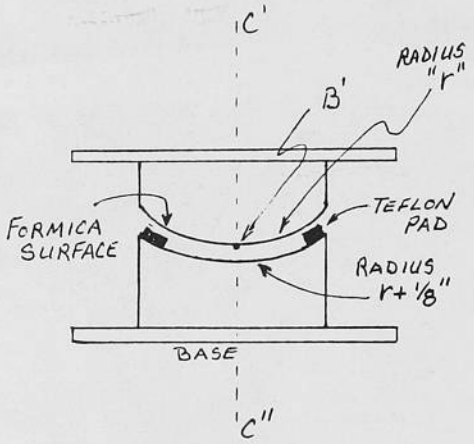
In the early planning stages, you should carefully lay out on the top of the base and underside of the platform so you know just where everything is going to be located. For example, the projection of point B should be marked on both surfaces for reference. This also includes a center line (your north-south line) on both surfaces and on both arc blocks. It will be from a single point C′ on an extension of line C′C″ that you



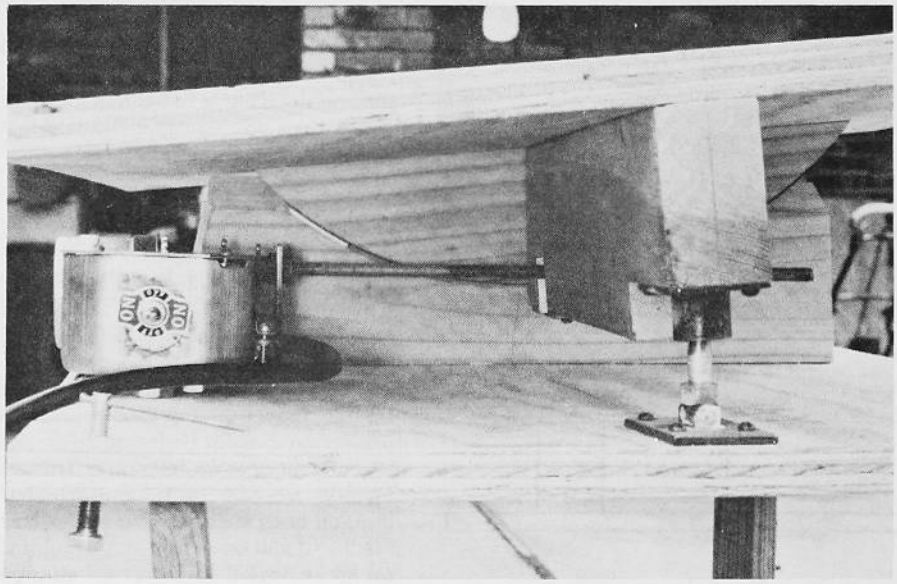
will draw the radii of the two curves.

I installed a 2x4 stiffening rib down the center line underside of the top. In this rib I mounted the gimbal with driving nut at B and the receiving plate and cup for the pivot pin at A. For convenience, the pin (a 5/16"x18 bolt with the head removed and filed to a narrow taper) comes up from the base. The threaded end goes into a nut soldered onto a small plate and its vertical position is held by a jam nut. The receiving cup is a small piece of bar stock which I drilled deep and narrow — just wide enough to receive the pin and allow plus or minus 10° of tilting movement but deep enough (about 3/4") to prevent its jumping off the pin.

I attached two Teflon pads, about 1½" square to the outside of the concave arc. Some careful measuring is required to properly locate the top and bottom arcs on their boards so that point B' is located on the surface of the convex arc at its center of thickness, and



so that the two curves fit together. In cutting the convex arc, I used a radius 1/16" less than C'B' to allow for the thickness of the Formica. Before you assemble it in place, glue the Formica to the arc with Weldwood contact cement.



The angles EFG and E'F'G' on the bases of the arc blocks are your co-latitude. Positioning these blocks can be difficult, but after some unsuccessful attempts other ways, I attached them using the center line along the underside of the top and a perpendicular line to it showing where edge F of the convex (top) block would be. I glued it in position with the Weldwood contact cement and reinforced it with three #8x1½" F.H. wood screws from the opposite side. I then "assembled" the top and bottom, cup on pin A, and positioned the concave block so that the top rotated smoothly over it. This turned out to be very close to my pre-measured position of this block, but I marked the new position carefully and attached it the same way I had the top block. In making this final positioning, take care that the top and bottom are parallel by adjusting the pivot pin.

In addition to the motor mount, I felt it necessary to protect the motor bearings against horizontal thrust, so I added a stanchion to absorb the thrust load. It slips between a nut fastened onto the threaded rod and the end of the universal joint where it connects to the rod.

To the baseboard I attached three 5/8"x18 fully-threaded bolts for leveling. These are in the two south corners and the center of the north side. I simply under-drilled the holes (with the tap-drill for the size bolt used) and screwed the bolts into the wood from the underside. 1/8" holes were drilled across the end of these bolts to provide accesses for 10d nails which can be bent to serve as drop-down crank handles.

A few final words: Remember that Poncet platform mounts are latitude-specific. Although they are not difficult to build, they do require careful measurement and cutting of the arc blocks. Positioning of the blocks and the driving nut are specific and must be made from point "A" and the N-S center line. The platform can be motorized either from a 115 VAC source or with an inverter (which can be expensive) from a 12 VDC source in the country, but I have not been able to locate a 12 VCD motor of similar torque and RPM.

A manual mechanical drive could be made easily — an old speedometer cable and housing serving to connect the observer to the threaded rod.

At the end of a 45 minute run, I reset the platform by disconnecting the threaded rod from the U-joint by pulling the cotter pin, turning the rod backward, then tilting the platform back and reconnecting the rod and U-joint.

Wally Pursell
12635 Parnell Ave.
Baton Rouge, LA 70815

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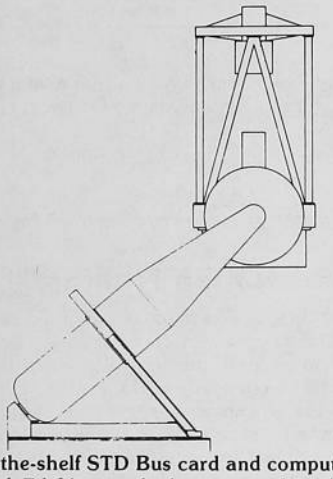
disruption of the diffraction image. Insofar as it can be misinterpreted to mean you can't slap a big eyepiece on the rear, I probably should have added a qualifier. — RLB

One-Meter Telescope

Richard / A fast update on the rapidly moving 1-meter project. The preliminary design has been completed on the mechanical portion of the telescope by Dr. Frank Melsheimer of DFM Engineering. It is going to be big — a person standing even with the base plate would barely clear the bottom of the mirror cell. The control system and electronics design is also well along. I am doing this portion of the design, and it is using



off-the-shelf STD Bus card and computer. I think Ed Olson and others were relieved that the alt-azimuth idea was not pursued further. Myself, I am a little sad in a way, but also greatly relieved. Mechanical design is not my bag, and Frank is an expert.

Russell M. Genet
Fairborn Observatory
1247 Folk Road
Fairborn, OH 45324

A Proposal for a Generic Telescope Mount

Dear Sir / Wouldn't it be nice if there were some sort of standardized equatorial mount that could take 13.1″ and under telescopes with very minor additions or modifications to the existing tubes (e.g., plywood cradles)? Note that this would unfortunately exclude unmodified Dobsonians because of their inability to keep the mirror supported when used outside of their designed altitude plane. Why waste a perfectly good mount just because the telescope mounted on it is inappropriate to the task? Here are some thoughts on the requirements of such a generic mount.

Rigidity — The German mount has the disadvantage of attaching to the telescope assembly on only one side, thus putting greater demands on the telescope structure; the counterweight nearly doubles the weight the polar axis must bear; and the unbalanced mass on the north end puts extra demands on bearing design. So the German design has its problems.

Also, unless you can design around the same problem of unbalanced load present on the polar axis in a forkmount with reasonable cost bearings, the cost to performance ratio on these designs would be higher than with other designs. If you can pull it off with the standardized minimum telescope width clearance, more power to you.

A wooden English yoke would provide both considerable strength and plenty of vibration damping as compared to metal mounts of any sort. A simple off-polar axis adaptor could be used if you really wanted to get to the pole badly enough. Using 4x4s for the yoke elements would probably provide at least a minimum of stability, but the larger and heavier (within reason), the better.

Standardized Minimum Yoke Arm Separation — If the mount is of the fork or English yoke design, the separation between the tines or arms must be specified as being some minimum amount. It must be done this way so that all potential users will know whether or not to expect their telescopes to fit the mount. Some may find it frustrating to drive 50 miles to a dark site only to find out that the yoke legs are ½″ too close together for their telescope to fit. I suggest 20″ as this minimum amount. Such a separation would provide a tight but not impossible fit for a homebuilt using a Coulter 13.1″ mirror with about 7″ of total side clearance. This becomes an attractive option since the 13.1″ optics are now available separately from the Odyssey I. Telescopes smaller than this would easily fit.

Low Cost Materials — Exterior plywood trusses would make delightfully rigid yoke arms. Why bother with metal when wood is so relatively easy to manipulate? If you are a metal-working fanatic, however, why not go to huge polar bearings running on babbitt — the Teflon of an earlier age? Perhaps you could even use a brakedrum lathe to turn such a bearing surface.

What I suggest for use as bearings, though it must prove out in practice, is ordinary pipe fittings. Thane Bopp's 17.5″ open frame mount was probably difficult to move only because of the unbalanced force applied to its elbow/nipple fitting. This is not a problem on either axis of a yoke mount or the declination axis of a fork. If thread bearings were to be lubricated with a "Lock-Ease" type of graphite-based lubricant, they may even work well in the dead of winter.

If the fixed flange/moving pipe strategy were adopted for the polar axis of the yoke mount, a piece of 3″ pipe slightly longer than the north to south yoke dimension could be fitted with a flange at each end. These flanges could then be securely attached one to each pier thus guaranteeing perfect flange to flange alignment. It looks like I just painted myself into a corner by preventing the removal of the pipe, doesn't it? But as long as we need both an upper and a lower polar axis bearing, why not take a hack saw to the pipe about 5-10″ from each flange, the exact amount depending upon what is required at the top and bottom attachment points on the yoke itself.

These short nipples of pipe would first be lapped in their respective flanges with very fine grit used wet just like when you grind your own mirror. After thorough cleaning and lubricating, they would be inserted into the north and south ends of the yoke, screwed tight into the flanges, and then backed out a half to a full turn. They would then be solidly clamped to the yoke during use. Rough polar alignment would be aided by having holes in the pier attachments at both ends for bore-sighting Polaris. Choice of the moving pipe/stationary flange arrangement would also allow easy installation of a tangent arm or sector drive clamping right onto the pipe, and could be either thread driven or cable pulled.

Declination Bearings — The standard should require that all telescope adaptors have a pair of 2″ pipe flanges on their sides. Two short pieces of 2″ pipe would be inserted from the outside, through the yoke arms, and into the flanges on the telescope adaptors in a manner described above and then clamped to the yoke arms in a fashion somewhat more easily reversible than that used at the north and south ends of the yoke. Don't forget to lap the flanges first just like you did on the polar bearings.

The outside ends of these declination nipples must have large wooden knobs attached so that cold, shivering astronomers can work them with gloved hands without experiencing the unspeakable joys of warm (?) hands sticking to freezing metal pipe. Slow motion could be affected by a tangent arm driven by threaded stock and a DC motor.This would run through a drive nut preloaded by a spring to minimize backlash. When you want to take telescope A out and put B in, just loosen the declination nipples in the yoke arms, take the telescope weight on your knee, remove A, put B on your knee, and then reverse the process.

DC "Clock" Drive — Why anyone in their right mind would use an AC motor to drive a telescope when they are going to have to apply drive correction anyway is beyond me. That $100-400 for a corrector is better spent on other accessories: A Venable or Edmund off-axis guide device, for example.

If you are not already an electronics hobbiest, here is the perfect opportunity to get your feet wet building the DC motor controls yourself. First get a copy of the current ARRL *Radio Amateur's Handbook* and read the chapters entitled "Electrical Laws and Circuits," "Solid State Fundamentals" and "AC-Operated Power Supplies," ignoring the high voltage supplies peculiar to tube-type ham transmitters. This will allow you to design your own AC power supply if you don't want to use a car battery. All of the devices used in a DC motor drive are so inexpensive that even if you build your own battery eliminator, you would have to really go out of your way to burn up a case of beer worth of parts. There's no point in being shy about a little project like this. Jump in and get your feet wet. Didn't you get into astronomy to learn new things anyway?

Two versions of the electronic gadget that you must build to vary the DC motor speed are described in detail in and around Figures 3-9 and 3-10 of Howard M. Berlin's book *The 555 Timer Applications Sourcebook, with Experiments* published by Howard W. Sams (#21538). All you have to do is add a power transistor or two and a 10-turn potentiometer

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for precision speed control. If you have trouble getting parts in your home town, a place called Alpha Labs (2302 Oakland Gravel Road, Columbia, MO 65201, 314-449-1362) probably has them. Make sure you pretty much know what you think you need before contacting them. They're very friendly, but busy. Ask for Don.

Here's wishing you power grid failures at night!

Footnotes:

1. *Telescope Making #8*, page 4.
2. *Sky & Telescope*, August 1982, page 177.

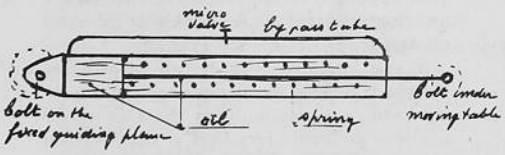
Fred Dittrich
reprinted from:
Central Missiouri Amateur Astronomers
CMAA Bulletin

Thanks for TM #17

Dear Richard / Thank you for TM #17.

I am glad to read that Bob Barclay's hydraulic escapement is working on the hinge equatorial of my Scotch friend Haig. If oil's viscosity comes in question, whisky or other alcohol may do the trick. However, the applied force, by the weight of the telescope, appears to be different according to its inclination — but is fairly constant for 5 to 15 minute observations.

I also thought of a hydraulic escapement for Poncet mounts (and also air), but I did not experiment, since I had some successful experience in other machines. The best way for a Poncet mount appears to be an oil pump



(cycle pump, about 1″ diameter) filled with oil, and a bypass tubing with a regulation valve. A long spring would give a constant force for an hour or less.

For best results, use a granite or stainless steel guiding plane on a concrete platform, oriented once for all, and force given by a mass (weight) cable and pulley. This allows immediate use of any azimuth mount, or photo tripod, camera, or tele-objectives.

Adrien Poncet
39300 Cotenay
France

Wanted: 12″ Blank

Dear Sir / As my next project, I would like to make a 12.5″ Dobsonian. I am looking for an affordable 12.5″ full thickness mirror blank. Any help with my search would be deeply appreciated.

Jason Maxwell
518 Ryan Court
W. Dundee, IL 60118

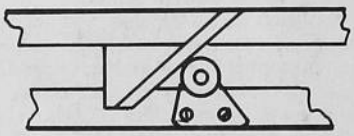
Our astronmy club (The Tacoma Astronomical Society) has a yearly "high altitude" star party in the Mt. Ranier National Park. Last year, after finding a wad of paper in my Odyssey, I came up with this cartoon. — Jerry Cotey

We think Mr. Cotey's just lucky they weren't on their way home from McDonald's . . . .

Platform Mods

Dear Sir / It was nice to see my article on the Hydraulic Platform so beautifully printed in TM. I like your editing too — smoothed out the writing and included several informative points. For example, it never occurred to me that a metal platform would be more prone to vibration and it was a good point to make. I was amused at your addition, after my words "declination control," of "of sorts." Right...

The projected low-profile platform is now complete and working, although I haven't done any test photography with it yet. It varies in a few details from the diagram in the TM#17 article, the most significant being a little wheel to make it more stable. This proved necessary because of flex in my welded construction hinge. I think it will be



a feature of this platform anyway — there's too much off-axis weight causing bending. This was slightly noticeable in the nested box design, even with its 24″ long hinge. The hydraulic declination adjustment-of-sorts works well in guiding tests through the high-power guiding scope. It shouldn't be long before I have sone good pictures to prove it.

Bob Barclay
3609 Downpatrick Road
Ottawa, Ontario K1V 9P4

"Dobsonian Making"?

Dear Sir / I'd like to comment on Telescope Making magazine if I may. It appears more and more that the title of the magazine should be changed to "Dobsonian Making" as we're being overrun with them. I just don't know what to think about them any longer; it's as if they are taking over the magazine, a "media priority" or similar.

I've been making telescopes for 22 years now and I enjoy seeing articles on projects giving design specifications and building hints, but it seems as though we only see pictures of Dobs nowadays.

We should let it be known that there is a whole world of telescope projects to build, and not just "wooden boxes" for dobs!

I believe the vast majority of builders are busy at projects of various interests from 3″ to 8″ aperture, and thus by feeding everyone a 20″ Dumb Dob., we are not catching a large public that might otherwise have use for the magazine.

Perhaps a survey on magazine direction.

Ray Reiffer
5685 Port Sheldon
Hudsonville, MI 49426

— Who needs a survey when the cold light of "total exposure" can be turned on the problem instead? Fact is that I'm running pretty much what I get from the TM readership, and as far as I can tell, there's a huge number of these large-aperture telescopes being built. I think the reason we've had so many pictures is that people are rightfully proud of their work.

I received several letters like yours, so I went back and counted articles on Dobsonians — they amount to a smaller number than even I thought they would. Let me ask you what you're doing at present — and may we hear from you on it? Please send photographs. . . .